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(54) Title: INORGANIC HYDROGEN AND HYDROGEN POLYMER COMPOUNDS AND APPLICATIONS THEREOF

(57) Abstract

Compounds are provided comprising at least one neutral, positive, or negative hydrogen species having a binding energy greater than its corresponding ordinary hydrogen species, or greater than any hydrogen species for which the corresponding ordinary hydrogen species is unstable or is not observed. Compounds comprise at least one increased binding energy hydrogen species and at least one other atom, molecule, or ion other than an increased binding energy hydrogen species. One group of such compounds contains one or more increased binding energy hydrogen species selected from the group consisting of H_n, H^-_n, and H^+_n where n is a positive integer, with the proviso that n is greater than 1 when H has a positive charge. Another group of such compounds may have the formula $[MH_mM'X]_n$ wherein m and n are each an integer, M and M' are each an alkali or alkaline earth cation, X is a singly or doubly negative charged anion, and the hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species. Method of forming the compounds and numerous applications are disclosed.

1

INORGANIC HYDROGEN AND HYDROGEN POLYMER COMPOUNDS AND APPLICATIONS THEREOF

TABLE OF CONTENTS

2

INORGANIC-HYDROGEN-POLYMER AND HYDROGEN-POLYMER COMPOUNDS AND APPLICATIONS THEREOF

I. INTRODUCTION

5

1. Field of the Invention:
This invention relates to novel compositions of matter comprising new forms of hydrogen.

10 ### 2. Background of the Invention
2.1 Hydrinos
A hydrogen atom having a binding energy given by

$$Binding\ Energy = \frac{13.6\ eV}{\left(\dfrac{1}{p}\right)^2}$$ (1)

where p is an integer greater than 1, preferably from 2 to 200, is
15 disclosed in Mills, R., The Grand Unified Theory of Classical Quantum Mechanics, January 1999 Edition (" '99 Mills GUT"), provided by BlackLight Power, Inc., 493 Old Trenton Road, Cranbury, NJ, 08512; and in prior PCT applications PCT/US98/14029; PCT/US96/07949; PCT/US94/02219; PCT/US91/8496; PCT/US90/1998; and prior US Patent
20 Applications Ser. No. 09/225,687, filed on January 6, 1999; Ser. No. 60/095,149, filed August 3, 1998; Ser. No. 60/101,651, filed September 24, 1998; Ser. No. 60/105,752, filed October 26, 1998; Ser. No. 60/113,713, filed December 24, 1998; Ser. No. 60/123,835, filed March 11, 1999; Ser. No. 60/130,491, filed April 22, 1999; Ser. No. 60/141,036,
25 filed June 29, 1999; Serial No. 09/009,294 filed January 20, 1998; Serial No. 09/111,160 filed July 7, 1998; Serial No. 09/111,170 filed July 7, 1998; Serial No. 09/111,016 filed July 7, 1998; Serial No. 09/111,003 filed July 7, 1998; Serial No. 09/110,694 filed July 7, 1998; Serial No. 09/110,717 filed July 7, 1998; Serial No. 60/053378 filed July 22, 1997;
30 Serial No. 60/068913 filed December 29, 1997; Serial No. 60/090239 filed June 22, 1998; Serial No. 09/009455 filed January 20, 1998; Serial No. 09/110,678 filed July 7, 1998; Serial No. 60/053,307 filed July 22, 1997; Serial No. 60/068918 filed December 29, 1997; Serial No. 60/080,725 filed April 3, 1998; Serial No. 09/181,180 filed October 28, 1998; Serial
35 No. 60/063,451 filed October 29, 1997; Serial No. 09/008,947 filed

3

January 20, 1998; Serial No. 60/074,006 filed February 9, 1998; Serial No. 60/080,647 filed April 3, 1998; Serial No. 09/009,837 filed January 20, 1998; Serial No. 08/822,170 filed March 27, 1997; Serial No. 08/592,712 filed January 26, 1996; Serial No. 08/467,051 filed on June 6, 1995; Serial

5   No. 08/416,040 filed on April 3, 1995; Serial No. 08/467,911 filed on June 6, 1995; Serial No. 08/107,357 filed on August 16, 1993; Serial No. 08/075,102 filed on June 11, 1993; Serial No. 07/626,496 filed on December 12,1990; Serial No. 07/345,628 filed April 28, 1989; Serial No. 07/341,733 filed April 21, 1989 the entire disclosures of which are all

10   incorporated herein by reference (hereinafter "Mills Prior Publications"). The binding energy, of an atom, ion or molecule, also known as the ionization energy, is the energy required to remove one electron from the atom, ion or molecule.

A hydrogen atom having the binding energy given in Eq. (1) is

15   hereafter referred to as a <u>hydrino atom or hydrino</u>. The designation for a hydrino of radius $\frac{a_H}{p}$,where a_H is the radius of an ordinary hydrogen atom and p is an integer, is $H\left[\frac{a_H}{p}\right]$. A hydrogen atom with a radius a_H is hereinafter referred to as "ordinary hydrogen atom" or "normal hydrogen atom." Ordinary atomic hydrogen is characterized by its binding energy

20   of 13.6 eV.

Hydrinos are formed by reacting an ordinary hydrogen atom with a catalyst having a net enthalpy of reaction of about

$$m \cdot 27.2 \, eV \qquad\qquad\qquad (2)$$

where m is an integer. This catalyst has also been referred to as an

25   energy hole or source of energy hole in Mills earlier filed Patent Applications. It is believed that the rate of catalysis is increased as the net enthalpy of reaction is more closely matched to $m \cdot 27.2 \, eV$. It has been found that catalysts having a net enthalpy of reaction within ±10%, preferably ±5%, of $m \cdot 27.2 \, eV$ are suitable for most applications.

30   This catalysis releases energy from the hydrogen atom with a commensurate decrease in size of the hydrogen atom, $r_n = na_H$. For example, the catalysis of $H(n=1)$ to $H(n=1/2)$ releases $40.8 \, eV$, and the hydrogen radius decreases from a_H to $\frac{1}{2}a_H$. One such catalytic system involves potassium. The second ionization energy of potassium is $31.63 \, eV$;

4

and K^+ releases $4.34\,eV$ when it is reduced to K. The combination of reactions K^+ to K^{2+} and K^+ to K, then, has a net enthalpy of reaction of $27.28\,eV$, which is equivalent to $m=1$ in Eq. (2).

$$27.28\,eV + K^+ + K^+ + H\left[\frac{a_H}{p}\right] \rightarrow K + K^{2+} + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]\,X\,13.6\,eV \qquad (3)$$

$$K + K^{2+} \rightarrow K^+ + K^+ + 27.28\,eV \qquad (4)$$

The overall reaction is

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]\,X\,13.6\,eV \qquad (5)$$
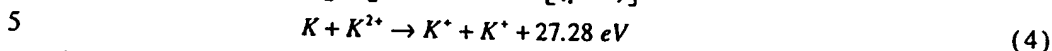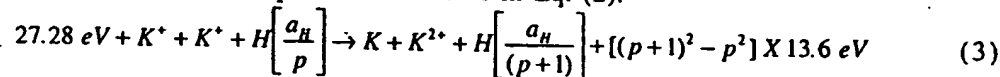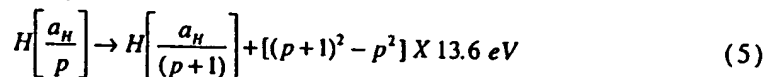
Rubidium ion (Rb^+) is also a catalyst because the second ionization energy of rubidium is $27.28\,eV$. In this case, the catalysis reaction is
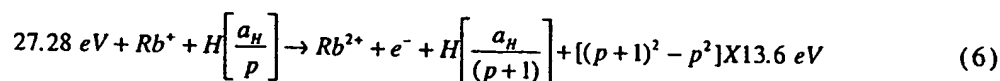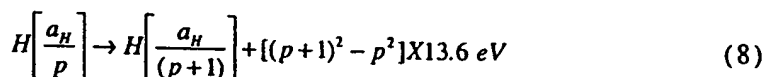
$$27.28\,eV + Rb^+ + H\left[\frac{a_H}{p}\right] \rightarrow Rb^{2+} + e^- + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]X13.6\,eV \qquad (6)$$

$$Rb^{2+} + e^- \rightarrow Rb^+ + 27.28\,eV \qquad (7)$$

And, the overall reaction is

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]X13.6\,eV \qquad (8)$$

The energy given off during catalysis is much greater than the energy lost to the catalyst. The energy released is large as compared to conventional chemical reactions. For example, when hydrogen and oxygen gases undergo combustion to form water

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O\,(l) \qquad (9)$$

the known enthalpy of formation of water is $\Delta H_f = -286\,kJ\,/\,mole$ or $1.48\,eV$ per hydrogen atom. By contrast, each ($n=1$) ordinary hydrogen atom undergoing catalysis releases a net of $40.8\,eV$. Moreover, further catalytic transitions may occur: $n = \frac{1}{2} \rightarrow \frac{1}{3}, \frac{1}{3} \rightarrow \frac{1}{4}, \frac{1}{4} \rightarrow \frac{1}{5}$, and so on. Once catalysis begins, hydrinos autocatalyze further in a process called disproportionation. This mechanism is similar to that of an inorganic ion catalysis. But, hydrino catalysis should have a higher reaction rate than that of the inorganic ion catalyst due to the better match of the enthalpy to $m \cdot 27.2\,eV$.

2.2   Hydride Ions

A hydride ion comprises two indistinguishable electrons bound to a proton.   Alkali and alkaline earth hydrides react violently with water to release hydrogen gas which burns in air ignited by the heat of the
5   reaction with water.   Typically metal hydrides decompose upon heating at a temperature well below the melting point of the parent metal.

II. SUMMARY OF THE INVENTION

An objective of the present invention is to provide novel compounds
10 that can be used in batteries, fuel cells, cutting materials, light weight high strength structural materials and synthetic fibers, corrosion resistant coatings, heat resistant coatings, xerographic compounds, proton source, photoluminescent compounds, phosphors for lighting, ultraviolet and visible light source, photoconductors, photovoltaics, chemiluminescent
15 compounds, fluorescent compounds, optical coatings, optical filters, extreme ultraviolet laser media, fiber optic cables, magnets and magnetic computer storage media, superconductors, and etching agents, masking agents, agents to purify silicon, dopants in semiconductor fabrication, cathodes for thermionic generators, fuels, explosives, and propellants.
20 Another objective is to provide compounds which may be useful in chemical synthetic processing methods and refining methods.

A further objective is to provide the negative ion of the electrolyte of a high voltage electrolytic cell.

A further objective is to provide a compound having a selective
25 reactivity in forming bonds with specific isotopes to provide a means to purify desired isotopes of elements.

The above objectives and other objectives are achieved by novel compounds and molecular ions comprising

(a) at least one neutral, positive, or negative hydrogen species
30 (hereinafter "increased binding energy hydrogen species") having a binding energy

(i) greater than the binding energy of the corresponding ordinary hydrogen species, or

(ii) greater than the binding energy of any hydrogen species
35 for which the corresponding ordinary hydrogen species is unstable or is not observed because the ordinary hydrogen species' binding energy is less than thermal energies at ambient conditions (standard temperature

6

and pressure, STP), or is negative; and

(b) at least one other element. The compounds of the invention are hereinafter referred to as "increased binding energy hydrogen compounds".

By "other element" in this context is meant an element other than an increased binding energy hydrogen species. Thus, the other element can be an ordinary hydrogen species, or any element other than hydrogen. In one group of compounds, the other element and the increased binding energy hydrogen species are neutral. In another group of compounds, the other element and increased binding energy hydrogen species are charged such that the other element provides the balancing charge to form a neutral compound. The former group of compounds is characterized by molecular and coordinate bonding; the latter group is characterized by ionic bonding.

Also provided are novel compounds and molecular ions comprising

(a) at least one neutral, positive, or negative hydrogen species (hereinafter "increased binding energy hydrogen species") having a total energy

(i) greater than the total energy of the corresponding ordinary hydrogen species, or

(ii) greater than the total energy of any hydrogen species for which the corresponding ordinary hydrogen species is unstable or is not observed because the ordinary hydrogen species' total energy is less than thermal energies at ambient conditions, or is negative; and

(b) at least one other element.

The total energy of the hydrogen species is the sum of the energies to remove all of the electrons from the hydrogen species. The hydrogen species according to the present invention has a total energy greater than the total energy of the corresponding ordinary hydrogen species. The hydrogen species having an increased total energy according to the present invention is also referred to as an "increased binding energy hydrogen species" even though some embodiments of the hydrogen species having an increased total energy may have a first electron binding energy less that the first electron binding energy of the corresponding ordinary hydrogen species. For example, the hydride ion of Eq. (10) for $p = 24$ has a first binding energy that is less than the first binding energy of ordinary hydride ion, while the total energy of the

7

hydride ion of Eq. (10) for $p = 24$ is much greater than the total energy of the corresponding ordinary hydride ion.

Also provided are novel compounds and molecular ions comprising

(a) a plurality of neutral, positive, or negative hydrogen species
5   (hereinafter "increased binding energy hydrogen species") having a binding energy

(i) greater than the binding energy of the corresponding ordinary hydrogen species, or

(ii) greater than the binding energy of any hydrogen species
10 for which the corresponding ordinary hydrogen species is unstable or is not observed because the ordinary hydrogen species' binding energy is less than thermal energies at ambient conditions or is negative; and

(b) optionally one other element. The compounds of the invention are hereinafter referred to as "increased binding energy hydrogen
15 compounds".

The increased binding energy hydrogen species can be formed by reacting one or more hydrino atoms with one or more of an electron, hydrino atom, a compound containing at least one of said increased binding energy hydrogen species, and at least one other atom, molecule,
20 or ion other than an increased binding energy hydrogen species.

Also provided are novel compounds and molecular ions comprising

(a) a plurality of neutral, positive, or negative hydrogen species (hereinafter "increased binding energy hydrogen species") having a total energy

25   (i) greater than the total energy of ordinary molecular hydrogen, or

(ii) greater than the total energy of any hydrogen species for which the corresponding ordinary hydrogen species is unstable or is not observed because the ordinary hydrogen species' total energy is less than
30 thermal energies at ambient conditions or is negative; and

(b) optionally one other element. The compounds of the invention are hereinafter referred to as "increased binding energy hydrogen compounds".

The total energy of the increased total energy hydrogen species is the
35 sum of the energies to remove all of the electrons from the increased total energy hydrogen species. The total energy of the ordinary hydrogen species is the sum of the energies to remove all of the electrons from the

8

ordinary hydrogen species. The increased total energy hydrogen species
is referred to as an increased binding energy hydrogen species, even
though some of the increased binding energy hydrogen species may have
a first electron binding energy less than the first electron binding energy
5   of ordinary molecular hydrogen.   However, the total energy of the
increased binding energy hydrogen species is much greater than the total
energy of ordinary molecular hydrogen.

In one embodiment of the invention, the increased binding energy
hydrogen species can be H_n, and H_n^- where n is a positive integer, or H_n^+
10   where n is a positive integer greater than one. Preferably, the increased
binding energy hydrogen species is H_n and H_n^- where n is an integer from
one to about $1 X 10^6$, more preferably one to about $1 X 10^4$, even more
preferably one to about $1 X 10^2$, and most preferably one to about 10, and
H_n^+ where n is an integer from two to about $1 X 10^6$, more preferably two
15   to about $1 X 10^4$, even more preferably two to about $1 X 10^2$, and most
preferably two to about 10. A specific example of H_n^- is H_{16}^-.

In an embodiment of the invention, the increased binding energy
hydrogen species can be H_n^{m-} where n and m are positive integers and H_n^{m+}
where n and m are positive integers with $m < n$. Preferably, the increased
20   binding energy hydrogen species is H_n^{m-} where n is an integer from one to
about $1 X 10^6$, more preferably one to about $1 X 10^4$, even more preferably
one to about $1 X 10^2$, and most preferably one to about 10 and m is an
integer from one to 100, one to ten, and H_n^{m+} where n is an integer from
two to about $1 X 10^6$, more preferably two to about $1 X 10^4$, even more
25   preferably two to about $1 X 10^2$, and most preferably two to about 10 and
m is one to about 100, preferably one to ten.

According to a preferred embodiment of the invention, a compound
is provided, comprising at least one increased binding energy hydrogen
species selected from the group consisting of (a) hydride ion having a
30   binding energy according to Eq. (10) that is greater than the binding of
ordinary hydride ion (about 0.8 eV) for $p = 2$ up to 23, and less for $p = 24$
("increased binding energy hydride ion" or "hydrino hydride ion"); (b)
hydrogen atom having a binding energy greater than the binding energy
of ordinary hydrogen atom (about 13.6 eV) ("increased binding energy
35   hydrogen atom" or "hydrino"); (c) hydrogen molecule having a first
binding energy greater than about 15.5 eV ("increased binding energy
hydrogen molecule" or "dihydrino"); and (d) molecular hydrogen ion

9

having a binding energy greater than about 16.4 eV ("increased binding energy molecular hydrogen ion" or "dihydrino molecular ion").

The compounds of the present invention are capable of exhibiting one or more unique properties which distinguishes them from the
5   corresponding compound comprising ordinary hydrogen, if such ordinary hydrogen compound exists. The unique properties include, for example, (a) a unique stoichiometry; (b) unique chemical structure; (c) one or more extraordinary chemical properties such as conductivity, melting point, boiling point, density, and refractive index; (d) unique reactivity to other
10   elements and compounds; (e) enhanced stability at room temperature and above; and/or (f) enhanced stability in air and/or water. Methods for distinguishing the increased binding energy hydrogen-containing compounds from compounds of ordinary hydrogen include: 1.) elemental analysis, 2.) solubility, 3.) reactivity, 4.) melting point, 5.) boiling point, 6.)
15   vapor pressure as a function of temperature, 7.) refractive index, 8.) X-ray photoelectron spectroscopy (XPS), 9.) gas chromatography, 10.) X-ray diffraction (XRD), 11.) calorimetry, 12.) infrared spectroscopy (IR), 13.) Raman spectroscopy, 14.) Mossbauer spectroscopy, 15.) extreme ultraviolet (EUV) emission and absorption spectroscopy, 16.) ultraviolet
20   (UV) emission and absorption spectroscopy, 17.) visible emission and absorption spectroscopy, 18.) nuclear magnetic resonance spectroscopy, 19.) gas phase mass spectroscopy of a heated sample (solids probe and direct exposure probe quadrapole and magnetic sector mass spectroscopy), 20.) time-of-flight-secondary-ion-mass-spectroscopy
25   (TOFSIMS), 21.) electrospray-ionization-time-of-flight-mass-spectroscopy (ESITOFMS), 22.) thermogravimetric analysis (TGA), 23.) differential thermal analysis (DTA), 24.) differential scanning calorimetry (DSC), 25.) liquid chromatography/mass spectroscopy (LCMS), and/or 26.) gas chromatography/mass spectroscopy (GCMS).
30   According to the present invention, a hydrino hydride ion (H⁻) having a binding energy according to Eq. (10) that is greater than the binding of ordinary hydride ion (about 0.8 eV) for $p = 2$ up to 23, and less for $p = 24$ (H⁻) is provided. For $p = 2$ to $p = 24$ of Eq. (10), the hydride ion binding energies are respectively 3, 6.6, 11.2, 16.7, 22.8, 29.3, 36.1, 42.8,
35   49.4, 55.5, 61.0, 65.6, 69.2, 71.5, 72.4, 715, 68.8, 64.0, 56.8, 47.1, 34.6, 19.2, and 0.65 eV. Compositions comprising the novel hydride ion are also provided.

The binding energy of the novel hydrino hydride ion can be represented by the following formula:

$$Binding\ Energy = \frac{\hbar^2\sqrt{s(s+1)}}{8\mu_e a_0^2\left[\dfrac{1+\sqrt{s(s+1)}}{p}\right]^2} - \frac{\pi\mu_0 e^2\hbar^2}{m_e^2 a_0^3}\left(1+\frac{2^2}{\left[\dfrac{1+\sqrt{s(s+1)}}{p}\right]^3}\right) \quad (10)$$

where p is an integer greater than one, $s = 1/2$, π is pi, $\hbar$ is Planck's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge.

The hydrino hydride ion of the present invention can be formed by the reaction of an electron source with a hydrino, that is, a hydrogen atom having a binding energy of about $\frac{13.6\ eV}{n^2}$, where $n = \frac{1}{p}$ and p is an integer greater than 1. The hydrino hydride ion is represented by $H^-(n = 1/p)$ or $H^-(1/p)$:

$$H\left[\frac{a_H}{p}\right] + e^- \rightarrow H^-(n = 1/p) \quad (11)a$$

$$H\left[\frac{a_H}{p}\right] + e^- \rightarrow H^-(1/p) \quad (11)b$$

The hydrino hydride ion is distinguished from an ordinary hydride ion comprising an ordinary hydrogen nucleus and two electrons having a binding energy of about 0.8 eV. The latter is hereafter referred to as "ordinary hydride ion" or "normal hydride ion" The hydrino hydride ion comprises a hydrogen nucleus including proteum, deuterium, or tritium, and two indistinguishable electrons at a binding energy according to Eq. (10).

The binding energies of the hydrino hydride ion, $H^-(n = 1/p)$ as a function of p, where p is an integer, are shown in TABLE 1.

TABLE 1. The representative binding energy of the hydrino hydride ion $H^-(n=1/p)$ as a function of p, Eq. (10).

Hydride Ion	r_1 (a_o)[a]	Binding Energy[b] (eV)	Wavelength (nm)
$H^-(n=1/2)$	0.9330	3.047	407
$H^-(n=1/3)$	0.6220	6.610	188
$H^-(n=1/4)$	0.4665	11.23	110
$H^-(n=1/5)$	0.3732	16.70	74.2
$H^-(n=1/6)$	0.3110	22.81	54.4
$H^-(n=1/7)$	0.2666	29.34	42.3
$H^-(n=1/8)$	0.2333	36.08	34.4
$H^-(n=1/9)$	0.2073	42.83	28.9
$H^-(n=1/10)$	0.1866	49.37	25.1
$H^-(n=1/11)$	0.1696	55.49	22.3
$H^-(n=1/12)$	0.1555	60.97	20.3
$H^-(n=1/13)$	0.1435	65.62	18.9
$H^-(n=1/14)$	0.1333	69.21	17.9
$H^-(n=1/15)$	0.1244	71.53	17.3
$H^-(n=1/16)$	0.1166	72.38	17.1

[a] Equation (51), infra.
[b] Equation (52), infra.

Novel compounds are provided comprising one or more hydrino hydride ions and one or more other elements. Such a compound is referred to as a **hydrino hydride compound.**

Ordinary hydrogen species are characterized by the following binding energies (a) hydride ion, 0.754 eV ("ordinary hydride ion"); (b) hydrogen atom ("ordinary hydrogen atom"), 13.6 eV; (c) diatomic hydrogen molecule, 15.46 eV ("ordinary hydrogen molecule"); (d) hydrogen molecular ion, 16.4 eV ("ordinary hydrogen molecular ion"); and (e) H_3^+, 22.6 eV ("ordinary trihydrogen molecular ion"). Herein, with reference to forms of hydrogen, "normal" and "ordinary" are synonymous.

According to a further preferred embodiment of the invention, a compound is provided comprising at least one increased binding energy

12

hydrogen species such as (a) a hydrogen atom having a binding energy of about $\dfrac{13.6\ eV}{\left(\dfrac{1}{p}\right)^2}$, preferably within ±10%,, more preferably ±5%, where p is

an integer, preferably an integer from 2 to 200; (b) a hydride ion (H^-) having a binding energy of about

$$\frac{\hbar^2\sqrt{s(s+1)}}{8\mu_e a_0^2\left[\dfrac{1+\sqrt{s(s+1)}}{p}\right]^2}-\frac{\pi\mu_0 e^2\hbar^2}{m_e^2 a_0^3}\left(1+\frac{2^2}{\left[\dfrac{1+\sqrt{s(s+1)}}{p}\right]^3}\right),\text{ preferably within ±10%, more}$$

preferably ±5%, where p is an integer, preferably an integer from 2 to 200, $s=1/2$, π is pi, $\hbar$ is Planck's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge; (c) $H_4^+(1/p)$; (d) a trihydrino molecular ion, $H_3^+(1/p)$, having a binding energy of about $\dfrac{22.6}{\left(\dfrac{1}{p}\right)^2}\ eV$ preferably within ±10%, more preferably ±5%, where p is an

integer, preferably an integer from 2 to 200; (e) a dihydrino having a binding energy of about $\dfrac{15.5}{\left(\dfrac{1}{p}\right)^2}\ eV$ preferably within ±10%, more preferably

±5%, where p is an integer, preferably and integer from 2 to 200; (f) a dihydrino molecular ion with a binding energy of about $\dfrac{16.4}{\left(\dfrac{1}{p}\right)^2}\ eV$

preferably within ±10%, more preferably ±5%, where p is an integer, preferably an integer from 2 to 200.

The compounds of the present invention are preferably greater than 50 atomic percent pure. More preferably, the compounds are greater than 90 atomic percent pure. Most preferably, the compounds are greater than 98 atomic percent pure.

According to one embodiment of the invention wherein the compound comprises a negatively charged increased binding energy hydrogen species, the compound further comprises one or more cations, such as a proton, ordinary H_2^+, or ordinary H_3^+.

The compounds of the invention further comprise one or more

13

normal hydrogen atoms and/or normal hydrogen molecules, in addition to the increased binding energy hydrogen species.

The compound may have the formula $MXM'H_n$ wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, X is a singly or doubly negative charged anion, M' is Si, Al, Ni, a transition element, an inner transition element, or a rare earth element, and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $MAlH_n$ wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula MH_n wherein n is an integer from 1 to 6, M is a transition element, an inner transition element, a rare earth element, or Ni, and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $MNiH_n$ wherein n is an integer from 1 to 6, M is an alkali cation, alkaline earth cation, silicon, or aluminum, and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $MM'H_n$ wherein n is an integer from 1 to 6, M is an alkali cation, alkaline earth cation, silicon, or aluminum, M' is a transition element, inner transition element, or a rare earth element cation, and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $MXAlX'H_n$ wherein n is 1 or 2, M is an alkali or alkaline earth cation, X and X' are either a singly negative charged anion or a doubly negative charged anion, and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula TiH_n wherein n is an integer from 1 to 4, and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula AlH_n wherein n is an integer from 1 to 4, and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula Al_2H_n wherein n is an integer

14

from 1 to 4, and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $[KH_mKCO_3]_n$ wherein m and n are each an integer, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $[KH_mKNO_3]_n^+ nX^-$ wherein m and n are each an integer, X is a singly negative charged anion, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $[KHKNO_3]_n$ wherein n is an integer and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $[KHKOH]_n$ wherein n is an integer and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

The compound including an anion or cation may have the formula $[MH_mM'X]_n$ wherein m and n are each an integer, M and M' are each an alkali or alkaline earth cation, X is a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species.

The compound including an anion or cation may have the formula $[MH_mM'X']_n^{m'+} n'X^-$ wherein m, m', n, and n' are each an integer, M and M' are each an alkali or alkaline earth cation, X and X' are a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species.

The compound including an anion or cation may have the formula $[MH_mM'X']_n^{m'-} n'M''^+$ wherein m, m', n, and n' are each an integer, M, M', and M'' are each an alkali or alkaline earth cation, X and X' are each a singly negative charged anion, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species.

The compound including an anion or cation may have the formula

15

$[MH_m]_n^{m'+} n' X^-$ wherein m, m', n, and n' are each an integer, M is alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, X is a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least

5   one increased binding energy hydrogen species.

The compound including an anion or cation may have the formula $[MH_m]_n^{m'-} n' M'^+$ wherein m, m', n, and n' are each an integer, M and M' are an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, the compound contains at least one H, and the

10   hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_{10})_n$ wherein n is an integer, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_{10})_n$ of the compound comprises at least one

15   increased binding energy hydrogen species.

The compound may have the formula $M(H_{10})_n$ wherein n is an integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{10})_n$ of the compound comprises at least one increased binding energy hydrogen species.

20   The compound may have the formula $M^+(H_{16})_n^-$ wherein n is an integer, M is other element such as an alkali, organic, organometalic, inorganic, or ammonium cation, and the hydrogen content $(H_{16})_n^-$ of the compound comprises at least one increased binding energy hydrogen species.

25   The compound may have the formula $M^+(H_{16})_n^-$ wherein n is an integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{16})_n^-$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_{16})_n$ wherein n is an

30   integer, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_{16})_n$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_{16})_n$ wherein n is an integer, M is an increased binding energy hydrogen compound, and the

35   hydrogen content $(H_{16})_n$ of the compound comprises at least one increased

16

binding energy hydrogen species.

The compound may have the formula $M(H_{24})_n$ wherein n is an integer, M is other element such as any atom, molecule, or compound; and the hydrogen content $(H_{24})_n$ of the compound comprises at least one

5   increased binding energy hydrogen species.

The compound may have the formula $M(H_{24})_n$ wherein n is an integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{24})_n$ of the compound comprises at least one increased binding energy hydrogen species.

10   The compound may have the formula $M(H_{60})_n$ wherein n is an integer, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_{60})_n$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_{60})_n$ wherein n is an

15   integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{60})_n$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_{70})_n$ wherein n is an integer, M is other element such as any atom, molecule, or compound, and

20   the hydrogen content $(H_{70})_n$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_{70})_n$ wherein n is an integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{70})_n$ of the compound comprises at least one increased

25   binding energy hydrogen species.

The compound may have the formula $M(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ wherein q, r, s, t, and u are each an integer including zero but not all zero, M is other element such as any atom, molecule, or compound, the monomers may be arranged in any order, and the hydrogen content

30   $(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ wherein q, r, s, and t are each an integer including zero but not all zero, M is an increased binding energy hydrogen compound, the monomers may

35   be arranged in any order, and the hydrogen content

17

$(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula MX wherein M is positive, neutral, or negative such as H_{16}, $H_{16}H$, $H_{16}H_2$, $H_{24}H_{23}$, OH_{22}, OH_{23}, OH_{24}, MgH_2H_{16}, NaH_3H_{16}, $H_{24}H_2O$, CNH_{16}, CH_{30}, SiH_4H_{16}, $(H_{16})_3H_{15}$, $SiH_4(H_{16})_2$, $(H_{16})_4$, H_{70}, $Si_2H_6H_{16}$, $(SiH_4)_2H_{16}$, $SiH_4(H_{16})_3$, CH_{70}, NH_{69}, NH_{70}, NHH_{70}, OH_{70}, H_2OH_{70}, FH_{70}, H_3OH_{70}, SiH_2H_{60}, $Si(H_{16})_3H_{15}$, $Si(H_{16})_4$, $Si_2H_6(H_{16})_2$, $Si_2H_7(H_{16})_2$, $SiH_3(H_{16})_4$, $(SiH_4)_2(H_{16})_2$, $O_2(H_{16})_4$, $SiH_4(H_{16})_4$, NOH_{70}, O_2H_{69}, $HONH_{70}$, O_2H_{70}, H_2ONH_{70}, $H_3O_2H_{70}$, $Si_2H_6(H_{24})_2$, $Si_2H_6(H_{16})_3$, $(SiH_4)_3H_{16}$, $(SiH_4)_2(H_{16})_3$, $(OH_{23})H_{16}H_{70}$, $(OH_{24})H_{16}H_{70}$, $Si_3H_{10}(H_{16})_2$, Si_2H_{70}, $Si_3H_{11}(H_{16})_2$, $Si_2H_7(H_{16})_4$, $(SiH_4)_3(H_{16})_2$, $(SiH_4)_2(H_{16})_4$, $NaOSiH_2(H_{16})_4$, $NaKH\,H_{70}$, $Si_2H_7(H_{70})$, $Si_3H_9(H_{16})_3$, $Si_3H_{10}(H_{16})_3$, $Si_2H_6(H_{16})_5$, $(SiH_4)_4H_{16}$, $(SiH_4)_3(H_{16})_3$, $Na_2OSiH_2(H_{16})_4$, $Si_3H_8(H_{16})_4$, $Na_2KH\,H_{70}$, $Si_3H_9(H_{16})_4$, $Na_2HKH\,H_{70}$, $SO(H_{16})_6(H_{15})$, $SH_2(OH_{23})H_{16}H_{70}$, $SO(H_{16})_7$, $Mg_2H_2H_{23}H_{16}H_{70}$, $(SiH_4)_4(H_{16})_2$, $(SiH_4)_3(H_{16})_4$, $KH_3O(H_{16})_2H_{70}$, $KH_5O(H_{16})_2H_{70}$, $K(OH_{23})H_{16}H_{70}$, $K_2OH\,H_{70}$, $NaKHO_2H_{70}$, $NaOHNaO_2\,H_{70}$, $HNO_3\,O_2\,H_{70}$, $Rb(H_{16})_5$, $Si_3H_{11}H_{70}$, $KNO_2(H_{16})_5$, $(SiH_4)_4(H_{16})_3$, $KKH(H_{16})_7$, $(SiH_4)_4(H_{16})_4$, $(KH_2)_2(H_{16})_3H_{70}$, $(NiH_2)_2HCl(H_{16})_2H_{70}$, Si_5OH_{102}, $(SiH_3)_7(H_{16})_5$, $Na_3O_3(SiH_3)_{10}SiH(H_{16})_5$, X is other element, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen.

The compound may have the formula MX wherein M is positive, neutral, or negative such as H_{16}, $H_{16}H$, $H_{16}H_2$, $H_{24}H_{23}$, OH_{22}, OH_{23}, OH_{24}, MgH_2H_{16}, NaH_3H_{16}, $H_{24}H_2O$, CNH_{16}, CH_{30}, SiH_4H_{16}, $(H_{16})_3H_{15}$, $SiH_4(H_{16})_2$, $(H_{16})_4$, H_{70}, $Si_2H_6H_{16}$, $(SiH_4)_2H_{16}$, $SiH_4(H_{16})_3$, CH_{70}, NH_{69}, NH_{70}, NHH_{70}, OH_{70}, H_2OH_{70}, FH_{70}, H_3OH_{70}, SiH_2H_{60}, $Si(H_{16})_3H_{15}$, $Si(H_{16})_4$, $Si_2H_6(H_{16})_2$, $Si_2H_7(H_{16})_2$, $SiH_3(H_{16})_4$, $(SiH_4)_2(H_{16})_2$, $O_2(H_{16})_4$, $SiH_4(H_{16})_4$, NOH_{70}, O_2H_{69}, $HONH_{70}$, O_2H_{70}, H_2ONH_{70}, $H_3O_2H_{70}$, $Si_2H_6(H_{24})_2$, $Si_2H_6(H_{16})_3$, $(SiH_4)_3H_{16}$, $(SiH_4)_2(H_{16})_3$, $(OH_{23})H_{16}H_{70}$, $(OH_{24})H_{16}H_{70}$, $Si_3H_{10}(H_{16})_2$, Si_2H_{70}, $Si_3H_{11}(H_{16})_2$, $Si_2H_7(H_{16})_4$, $(SiH_4)_3(H_{16})_2$, $(SiH_4)_2(H_{16})_4$, $NaOSiH_2(H_{16})_4$, $NaKH\,H_{70}$, $Si_2H_7(H_{70})$, $Si_3H_9(H_{16})_3$, $Si_3H_{10}(H_{16})_3$, $Si_2H_6(H_{16})_5$, $(SiH_4)_4H_{16}$, $(SiH_4)_3(H_{16})_3$, $Na_2OSiH_2(H_{16})_4$, $Si_3H_8(H_{16})_4$, $Na_2KH\,H_{70}$, $Si_3H_9(H_{16})_4$, $Na_2HKH\,H_{70}$, $SO(H_{16})_6(H_{15})$, $SH_2(OH_{23})H_{16}H_{70}$, $SO(H_{16})_7$, $Mg_2H_2H_{23}H_{16}H_{70}$, $(SiH_4)_4(H_{16})_2$, $(SiH_4)_3(H_{16})_4$, $KH_3O(H_{16})_2H_{70}$, $KH_5O(H_{16})_2H_{70}$, $K(OH_{23})H_{16}H_{70}$, $K_2OH\,H_{70}$, $NaKHO_2H_{70}$, $NaOHNaO_2\,H_{70}$, $HNO_3\,O_2\,H_{70}$, $Rb(H_{16})_5$, $Si_3H_{11}H_{70}$, $KNO_2(H_{16})_5$, $(SiH_4)_4(H_{16})_3$, $KKH(H_{16})_7$, $(SiH_4)_4(H_{16})_4$, $(KH_2)_2(H_{16})_3H_{70}$, $(NiH_2)_2HCl(H_{16})_2H_{70}$, Si_5OH_{102}, $(SiH_3)_7(H_{16})_5$, $Na_3O_3(SiH_3)_{10}SiH(H_{16})_5$, X is an increased binding energy hydrogen compound, and the hydrogen content H of the compound

18

comprises at least one increased binding energy hydrogen.

The compound may have the formula $M(H_x)_n$ wherein n is an integer, x is an integer from 8 to 12, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_x)_n$ wherein n is an integer, x is an integer from 8 to 12, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M^+(H_x)_n^-$ wherein n is an integer, x is an integer from 14 to 18, M is other element such as an alkali, organic, organometalic, inorganic, or ammonium cation, and the hydrogen content $(H_x)_n^-$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M^+(H_x)_n^-$ wherein n is an integer, x is an integer from 14 to 18, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n^-$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_x)_n$ wherein n is an integer, x is an integer from 14 to 18, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_x)_n$ wherein n is an integer, x is an integer from 14 to 18, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_x)_n$ wherein n is an integer, x is an integer from 22 to 26, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_x)_n$ wherein n is an integer, x is an integer from 22 to 26, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n$ of the compound

comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_x)_n$ wherein n is an integer, x is an integer from 58 to 62, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_x)_n$ of the

5 compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_x)_n$ wherein n is an integer, x is an integer from 58 to 62, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n$ of the compound

10 comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_x)_n$ wherein n is an integer, x is an integer from 68 to 72, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen

15 species.

The compound may have the formula $M(H_x)_n$ wherein n is an integer, x is an integer from 68 to 72, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

20 The compound may have the formula $M(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ wherein q, r, s, t, and u are each an integer including zero but not all zero, x is an integer from 8 to 12, x' is an integer from 14 to 18, y is an integer from 22 to 26, y' is an integer from 58 to 62, z is an integer from 68 to 72, M is other element such as any atom, molecule, or compound, the

25 monomers may be arranged in any order, and the hydrogen content $(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ of the compound comprises at least one increased binding energy hydrogen species.

The compound may have the formula $M(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ wherein q, r, s, t, and u are each an integer including zero but not all zero,

30 x is an integer from 8 to 12, x' is an integer from 14 to 18, y is an integer from 22 to 26, y' is an integer from 58 to 62, z is an integer from 68 to 72, M is an increased binding energy hydrogen compound, the monomers may be arranged in any order, and the hydrogen content $(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ of the compound comprises at least one increased

35 binding energy hydrogen species.

20

The polymer compound may have the formula comprising one or more monomers in any order selected from the group comprising $[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$ wherein p, q, r, s, and t are integers, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen.

The polymer compound may have the formula comprising one or more monomers in any order selected from the group comprising $[MH_m]_n[MM'\,H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+\,nX^-[KHKNO_3]_n$ $[KHKOH]_n[MH_mM'\,X]_n[MH_mM'\,X]_n^{m'+}\,n'X^-[MH_mM'\,X]_n^{m'-}\,n'M''^+[MH_m]_n^{m'+}\,n'X^-$ $[MH_m]_n^{m'-}\,n'M^+\,M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$ wherein n, n', m, m', p, q, r, s, and t are integers, M, M' and M'' are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, X and X' are a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

The polymer compound may have the formula comprising one or more monomers in any order selected from the group comprising $[MH_m]_n[MM'\,H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+\,nX^-[KHKNO_3]_n$ $[KHKOH]_n[MH_mM'\,X]_n[MH_mM'\,X]_n^{m'+}\,n'X^-[MH_mM'\,X]_n^{m'-}\,n'M''^+[MH_m]_n^{m'+}\,n'X^-$ $[MH_m]_n^{m'-}\,n'M^+\,M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$ $M'''(H_{10})_{q'}(H_{16})_{r'}(H_{24})_{s'}(H_{60})_{t'}(H_{70})_u$ wherein n, n', m, m', p, q, r, s, t, q', r', s', t', and u are each an integer, M, M' and M'' are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, M''' is other element, X and X' are a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

The polymer compound may have the formula comprising one or more monomers in any order selected from the group comprising $[MH_m]_n[MM'\,H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+\,nX^-[KHKNO_3]_n$ $[KHKOH]_n[MH_mM'\,X]_n[MH_mM'\,X]_n^{m'+}\,n'X^-[MH_mM'\,X]_n^{m'-}\,n'M''^+[MH_m]_n^{m'+}\,n'X^-$ $[MH_m]_n^{m'-}\,n'M^+\,M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$ $M'''(H_{10})_{q'}(H_{16})_{r'}(H_{24})_{s'}(H_{60})_{t'}(H_{70})_u$ wherein n, n', m, m', p, q, r, s, t, q', r', s', t', and u are each an integer, M, M' and M'' are each an alkali or alkaline

21

earth, organic, organometalic, inorganic, or ammonium cation, M''' is an increased binding energy hydrogen compound, X and X' are a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one increased

5 binding energy hydrogen species.

The polymer compound may have the formula comprising one or more monomers in any order selected from the group comprising

$$[MH_m]_n [MM'H_m]_n [KH_mKCO_3]_n [KH_mKNO_3]_n^+ nX^- [KHKNO_3]_n$$

$$[KHKOH]_n [MH_mM'X]_n [MH_mM'X]_n^{m'+} n'X^- [MH_mM'X]_n^{m'-} n'M'^+ [MH_m]_n^{m'+} n'X^-$$

10 $$[MH_m]_n^{m'-} n'M^+ M^+H_{16}^- [KHKOH]_p [KH_5KOH]_q [KH KHCO_3]_r [KHCO_3]_s [K_2CO_3]_t$$

$$M'''(H_x)_q (H_{x'})_r (H_y)_s (H_{y'})_t (H_z)_u,$$ wherein n, n', m, m', p, q, r, s, t, q', r', s', t', and

u are each an integer, x is an integer from 8 to 12, x' is an integer from 14 to 18, y is an integer from 22 to 26, y' is an integer from 58 to 62, z is an integer from 68 to 72, M, M' and M'' are each an alkali or alkaline earth,

15 organic, organometalic, inorganic, or ammonium cation, M''' is other element, X and X' are a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

20 The polymer compound may have the formula comprising one or more monomers in any order selected from the group comprising

$$[MH_m]_n [MM'H_m]_n [KH_mKCO_3]_n [KH_mKNO_3]_n^+ nX^- [KHKNO_3]_n$$

$$[KHKOH]_n [MH_mM'X]_n [MH_mM'X]_n^{m'+} n'X^- [MH_mM'X]_n^{m'-} n'M'^+ [MH_m]_n^{m'+} n'X^-$$

$$[MH_m]_n^{m'-} n'M^+ M^+H_{16}^- [KHKOH]_p [KH_5KOH]_q [KH KHCO_3]_r [KHCO_3]_s [K_2CO_3]_t$$

25 $$M'''(H_x)_q (H_{x'})_r (H_y)_s (H_{y'})_t (H_z)_u,$$ wherein n, n', m, m', p, q, r, s, t, q', r', s', t', and

u are each an integer, x is an integer from 8 to 12, x' is an integer from 14 to 18, y is an integer from 22 to 26, y' is an integer from 58 to 62, z is an integer from 68 to 72, M, M' and M'' are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, M''' is an

30 increased binding energy hydrogen compound, X and X' are a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

The polymer compound may have the formula comprising one or

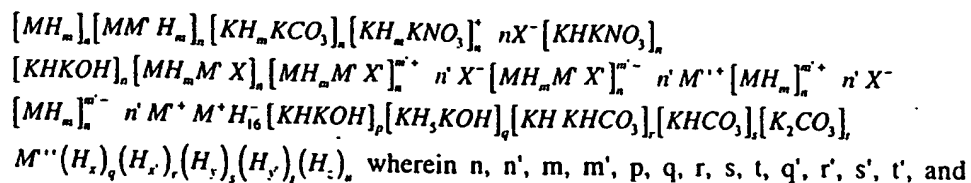35 more monomers in any order selected from the group comprising

22

$[MH_m]_t[MM'H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+ nX^-[KHKNO_3]_n$

$[KHKOH]_s[MH_mM'X]_n[MH_mM'X]_n^{n'+} n'X^-[MH_mM'X]_n^{n'-} n'M'^+[MH_m]_n^{n'+} n'X^-$

$[MH_m]_n^{n'-} n'M^+ M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$

$M'''(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ wherein n, n', m, m', p, q, r, s, t, q', r', s', t', and

5   u are each an integer, x is an integer from 8 to 12, x' is an integer from 14 to 18, y is an integer from 22 to 26, y' is an integer from 58 to 62, z is an integer from 68 to 72, M, M' and M'' are each a metal such as a transition metal, inner transition metal, tin, boron, or a rare earth, lanthanide, an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium

10   cation, M'''' is other element, X and X' are a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

The polymer compound may have the formula comprising one or

15   more monomers in any order selected from the group comprising
$[MH_m]_t[MM'H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+ nX^-[KHKNO_3]_n$

$[KHKOH]_s[MH_mM'X]_n[MH_mM'X]_n^{n'+} n'X^-[MH_mM'X]_n^{n'-} n'M'^+[MH_m]_n^{n'+} n'X^-$

$[MH_m]_n^{n'-} n'M^+ M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$

$M'''(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ wherein n, n', m, m', p, q, r, s, t, q', r', s', t', and

20   u are each an integer, x is an integer from 8 to 12, x' is an integer from 14 to 18, y is an integer from 22 to 26, y' is an integer from 58 to 62, z is an integer from 68 to 72, M, M' and M'' are each a metal such as a transition metal, inner transition metal, tin, boron, or a rare earth, lanthanide, an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium

25   cation, M'''' is an increased binding energy hydrogen compound, X and X' are a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

The polymer compound may have the formula $Si_xH_y(H_{16})_z$ wherein x

30   is an integer, y is an integer from 2x+2 to 4x, z is an integer, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

The polymers described herein can be formulated to any desired molecular weight for the particular application. Examples of suitable

35   number average molecular weights include from about 3 up to about

23

$1 X 10^7$. Polymers based primarily on hydrinos usually have a molecular weight towards the lower molecular weight range, while polymers containing heavy elements such as silicon usually have higher molecular weights.

Examples of singly negative charged anions of the increased binding energy hydrogen compounds disclosed herein include but are not limited to halogen ions, hydroxide ion, dihydrogen phosphate ion, hydrogen carbonate ion, and nitrate ion. Examples of doubly negative charged anions of the increased binding energy hydrogen compounds disclosed herein include but are not limited to carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion.

Applications of the compounds include use in batteries, fuel cells, cutting materials, light weight high strength structural materials and synthetic fibers, corrosion resistant coatings, heat resistant coatings, xerographic compounds, proton source, photoluminescent compounds, phosphors for lighting, photoconductors, photovoltaics, chemiluminescent compounds, fluorescent compounds, optical coatings, optical filters, extreme ultraviolet laser media, fiber optic cables, magnets and magnetic computer storage media, superconductors, and etching agents, masking agents, agents to purify silicon, dopants in semiconductor fabrication, cathodes for thermionic generators, fuels, explosives, and propellants. Increased binding energy hydrogen compounds are useful in chemical synthetic processing methods and refining methods. The increased binding energy hydrogen ion and the increased binding energy hydrogen molecular ion have application as the negative ion of the electrolyte of a high voltage electrolytic cell. The selectivity of increased binding energy hydrogen species in forming bonds with specific isotopes provides a means to purify desired isotopes of elements.

Alkali halides are known to be transparent to infrared radiation. A colored increased binding energy compound comprising an alkali or alkaline earth halide and at least one increased binding energy hydrogen species such as a hydrino hydride ion may be a medium to optically amplify infrared signals such as telecommunications signals. Two exemplary compounds are blue crystals of *KHI* and magenta crystals of *KHCl*. In another embodiment of a colored compound to amplify infrared light, F centers color the compound. F centers may be formed in an uncolored compound during the catalysis of hydrogen in the presence of

24

the compound. The uncolored compound which is colored by formation of F centers may comprise an alkaline or alkaline earth halide.

According to another aspect of the invention, dihydrinos, can be produced by reacting protons with hydrino hydride ions, or by the
5 thermal decomposition of hydrino hydride ions, or by the thermal or chemical decomposition of increased binding energy hydrogen compounds. For example, the hydrino hydride compound $KH(1/p)$ or $K(H(1/p))_2 I$ may react with a source of oxygen such as oxygen gas or water to form dihydrino and potassium oxide wherein the hydrino hydride ion has a
10 relatively low binding energy such as $H^-(1/2)$.

$$2KH(1/2)+1/2O_2 \rightarrow H_2^* \left[2c' = \frac{a_n}{\sqrt{2}} \right] + K_2O \qquad (12)$$
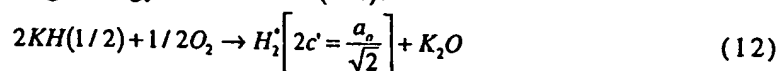
Alternatively, the hydrino hydride compound may be heated to release dihydrino by thermal decomposition.

$$2KH(1/2) \xrightarrow{\Delta} H_2^* \left[2c' = \frac{a_o}{\sqrt{2}} \right] + 2K_{(m)} \qquad (13)$$
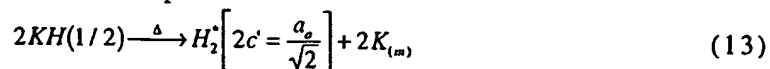
15 In both cases, the dihydrino product may be analyzed by gas chromatography.

A method is provided for preparing compounds comprising at least one increased binding energy hydride ion. Such compounds are hereinafter referred to as "hydrino hydride compounds". The method
20 comprises reacting atomic hydrogen with a catalyst having a net enthalpy of reaction of about $\frac{m}{2} \cdot 27\, eV$, where m is an integer greater than 1,

preferably an integer less than 400, to produce an increased binding energy hydrogen atom having a binding energy of about $\dfrac{13.6\, eV}{\left(\dfrac{1}{p} \right)^2}$ where p

is an integer, preferably an integer from 2 to 200. A further product of
25 the catalysis is energy. The increased binding energy hydrogen atom can be reacted with an electron source, to produce an increased binding energy hydride ion. The increased binding energy hydride ion can be reacted with one or more cations to produce a compound comprising at least one increased binding energy hydride ion.
30 The invention is also directed to a reactor for producing increased binding energy hydrogen compounds of the invention, such as hydrino hydride compounds. A further product of the catalysis is energy. Such a

2 5

reactor is hereinafter referred to as a "hydrino hydride reactor". The hydrino hydride reactor comprises a cell for making hydrinos and an electron source. The reactor produces hydride ions having the binding energy of Eq. (10). The cell for making hydrinos may take the form of an

5   electrolytic cell, a gas cell, a gas discharge cell, or a plasma torch cell, for example. Each of these cells comprises: a source of atomic hydrogen; at least one of a solid, molten, liquid, or gaseous catalyst for making hydrinos; and a vessel for reacting hydrogen and the catalyst for making hydrinos. As used herein and as contemplated by the subject invention,

10 the term "hydrogen", unless specified otherwise, includes not only proteum (^1H), but also deuterium (^2H) and tritium (^3H). Electrons from the electron source contact the hydrinos and react to form hydrino hydride ions.

The reactors described herein as "hydrino hydride reactors" are

15 capable of producing not only hydrino hydride ions and compounds, but also the other increased binding energy hydrogen compounds of the present invention. Hence, the designation "hydrino hydride reactors" should not be understood as being limiting with respect to the nature of the increased binding energy hydrogen compound produced.
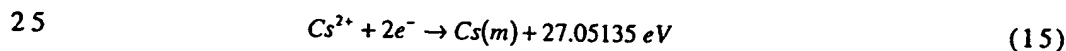
20   According to one aspect of the present invention, novel compounds are formed from hydrino hydride ions and cations. In the electrolytic cell, the cation may be either an oxidized species of the material of the cell cathode or anode, a cation of an added reductant, or a cation of the electrolyte (such as a cation comprising the catalyst). The cation of the

25 electrolyte may be a cation of the catalyst. In the gas cell, the cation can be an oxidized species of the material of the cell, a cation comprising the molecular hydrogen dissociation material which produces atomic hydrogen, a cation comprising an added reductant, or a cation present in the cell (such as a cation comprising the catalyst). In the discharge cell,

30 the cation can be an oxidized species of the material of the cathode or anode, a cation of an added reductant, or a cation present in the cell (such as a cation comprising the catalyst). In the plasma torch cell, the cation can be either an oxidized species of the material of the cell, a cation of an added reductant, or a cation present in the cell (such as a cation

35 comprising the catalyst).

Catalysts

A catalyst, of the present invention can be an increased binding energy hydrogen compound having a net enthalpy of reaction of about $\fra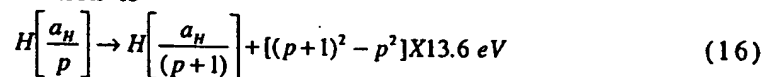c{m}{2} \cdot 27\, eV$, where m is an integer greater than 1, preferably an integer less than 400, to produce an increased binding energy hydrogen atom having a binding energy of about $\frac{13.6\, eV}{\left(\frac{1}{p}\right)^2}$ where p is an integer, preferably an integer from 2 to 200.

t Electron Transfer (One Species)

In another embodiment, a catalytic system is provided by the ionization of *t* electrons from a participating species such as an atom, an ion, a molecule, and an ionic or molecular compound to a continuum energy level such that the sum of the ionization energies of the *t* electrons is approximately $m \times 27.2\, eV$ where *m* is an integer. One such catalytic system involves cesium. The first and second ionization energies of cesium are $3.89390\, eV$ and $23.15745\, eV$, respectively [David R. Linde, CRC Handbook of Chemistry and Physics, 74 th Edition, CRC Press, Boca Raton, Florida, (1993), p. 10-207]. The double ionization $(t=2)$ reaction of Cs to Cs^{2+}, then, has a net enthalpy of reaction of $27.05135\, eV$, which is equivalent to $m=1$ in Eq. (2).

$$27.05135\, eV + Cs(m) + H\left[\frac{a_H}{p}\right] \rightarrow Cs^{2+} + 2e^- + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]X13.6\, eV$$

$$\tag{14}$$

$$Cs^{2+} + 2e^- \rightarrow Cs(m) + 27.05135\, eV \tag{15}$$

And, the overall reaction is

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]X13.6\, eV \tag{16}$$
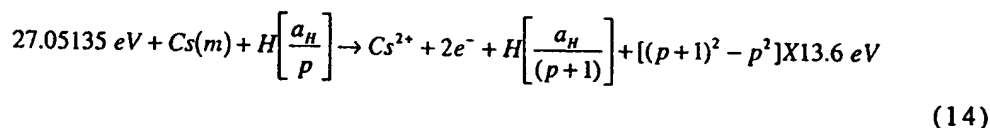
Thermal energies may broaden the enthalpy of reaction. The relationship between kinetic energy and temperature is given by

$$E_{kinetic} = \frac{3}{2}kT \tag{17}$$

For a temperature of 1200 K, the thermal energy is 0.16 eV, and the net enthalpy of reaction provided by cesium metal is 27.21 eV which is

an exact match to the desired energy.

Hydrogen catalysts capable of providing a net enthalpy of reaction of approximately $m \times 27.2\ eV$ where m is an integer to produce hydrino whereby t electrons are ionized from an atom or ion are given *infra*. A

5   further product of the catalysis is energy. The atoms or ions given in the first column are ionized to provide the net enthalpy of reaction of $m \times 27.2\ eV$ given in the tenth column where m is given in the eleventh column. The electrons which are ionized are given with the ionization potential (also called ionization energy or binding energy). The ionization

10   potential of the nth electron of the atom or ion is designated by IP_n and is given by David R. Linde, CRC Handbook of Chemistry and Physics, 78 th Edition, CRC Press, Boca Raton, Florida, (1997), p. 10-214 to 10-216 which is herein incorporated by reference. That is for example, $Cs + 3.89390\ eV \rightarrow Cs^+ + e^-$ and $Cs^+ + 23.15745\ eV \rightarrow Cs^{2+} + e^-$. The first ionization

15   potential, $IP_1 = 3.89390\ eV$, and the second ionization potential, $IP_2 = 23.15745\ eV$, are given in the second and third columns, respectively. The net enthalpy of reaction for the double ionization of Cs is $27.05135\ eV$ as given in the tenth column, and $m = 1$ in Eq. (2) as given in the eleventh column.

20

Catalyst	IP1	IP2	IP3	IP4	IP5	IP6	IP7	IP8	Enthalpy	m
Li	5.39172	75.6402							81.032	3
Be	9.32263	18.2112							27.534	1
K	4.34066	31.63	45.806						81.777	3
Ca	6.11316	11.8717	50.9131	67.27					136.17	5
Ti	6.8282	13.5755	27.4917	43.267	99.3				190.46	7
V	6.7463	14.66	29.311	46.709	65.2817				162.71	6
Cr	6.76664	16.4857	30.96						54.212	2
Mn	7.43402	15.64	33.668	51.2					107.94	4
Fe	7.9024	16.1878	30.652						54.742	2
Fe	7.9024	16.1878	30.652	54.8					109.54	4
Co	7.881	17.083	33.5	51.3					109.76	4
Co	7.881	17.083	33.5	51.3	79.5				189.26	7
Ni	7.6398	18.1688	35.19	54.9	76.06				191.96	7
Ni	7.6398	18.1688	35.19	54.9	76.06	108			299.96	11
Cu	7.72638	20.2924							28.019	1
Zn	9.39405	17.9644							27.358	1
Zn	9.39405	17.9644	39.723	59.4	82.6	108	134	174	625.08	23
As	9.8152	18.633	28.351	50.13	62.63	127.6			297.16	11
Se	9.75238	21.19	30.8204	42.945	68.3	81.7	155.4		410.11	15
Kr	13.9996	24.3599	36.95	52.5	64.7	78.5			271.01	10
Kr	13.9996	24.3599	36.95	52.5	64.7	78.5	111		382.01	14
Rb	4.17713	27.285	40	52.6	71	84.4	99.2		378.66	14
Rb	4.17713	27.285	40	52.6	71	84.4	99.2	136	514.66	19
Sr	5.69484	11.0301	42.89	57	71.6				188.21	7
Nb	6.75885	14.32	25.04	38.3	50.55				134.97	5
Mo	7.09243	16.16	27.13	46.4	54.49	68.8276			151.27	8
Mo	7.09243	16.16	27.13	46.4	54.49	68.8276	125.664	143.6	489.36	18
Pd	8.3369	19.43							27.767	1
Sn	7.34381	14.6323	30.5026	40.735	72.28				165.49	6
Te	9.0096	18.6							27.61	1
Te	9.0096	18.6	27.96						55.57	2
Cs	3.8939	23.1575							27.051	1
Ce	5.5387	10.85	20.198	36.758	65.55				138.89	5
Ce	5.5387	10.85	20.198	36.758	65.55	77.6			216.49	8
Pr	5.464	10.55	21.624	38.98	57.53				134.15	5
Sm	5.6437	11.07	23.4	41.4					81.514	3
Gd	6.15	12.09	20.63	44					82.87	3
Dy	5.9389	11.67	22.8	41.47					81.879	3
Pb	7.41666	15.0322	31.9373						54.386	2
Pt	8.9587	18.563							27.522	1
He+		54.4178							54.418	2
Rb+		27.285							27.285	1
Fe3+				54.8					54.8	2
Mo2+			27.13						27.13	1
Mo4+					54.49				54.49	2
In3+				54					54	2

29

Two Electron Transfer(Two Species): $m = 1$ in Eq. (2)

In another embodiment, a catalytic system transfers an electron to a vacuum energy level from each of two species selected from the set of atom, ion, or molecule such that the sum of the ionization energies of the

5   participating atoms, ions, and/or molecules is approximately $m \times 27.2\,eV$ where m is an integer. One such catalytic system involves cesium. The first and second ionization energies of cesium are $3.89390\,eV$ and $23.15745\,eV$, respectively. The combination of reactions Cs to Cs^+ and Cs^+ to Cs^{2+}, then, has a net enthalpy of reaction of $27.05135\,eV$, which is

10   equivalent to $m = 1$ in Eq. (2).

$$27.05135\,eV + Cs + Cs^+ + H\left[\frac{a_H}{p}\right] \rightarrow Cs^+ + Cs^{2+} + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2] \times 13.6\,eV$$

(18)

$$Cs^+ + Cs^{2+} \rightarrow Cs + Cs^+ + 27.05135\,eV$$

(19)

The overall reaction is

15

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2] \times 13.6\,eV$$

(20)

Hydrogen catalysts capable of providing a net enthalpy of reaction of approximately $27.2\,eV$ to produce hydrino whereby each of two atoms or ions are oxidized are given *infra*. The atoms or ions in the first and

20   fourth columns are oxidized to provide the net enthalpy of reaction. The number in the column following the atom or ion, (n), is the nth ionization energy of the atom or ion. That is for example, $Cs + 3.89390\,eV \rightarrow Cs^+ + e^-$ and $Cs^+ + 23.15745\,eV \rightarrow Cs^{2+} + e^-$. The net enthalpy of reaction for oxidation of Cs and Cs^+ is $27.05135\,eV$ as given in the seventh column.

25

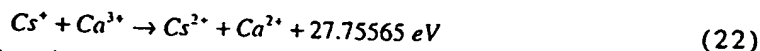| First Atom or Ion Oxidized	n th Ionization	n th Ionization Energy (eV)	Second Atom or Ion Oxidized	n th Ionization	n th Ionization Energy (eV)	Net Enthalpy of Reaction of Catalyst (eV)
Li	1	5.39172	Cs^+	2	23.15745	28.54917
Na	1	5.13908	Cs^+	2	23.15745	28.29653
K	1	4.34066	Cs^+	2	23.15745	27.49811
Rb	1	4.17713	Cs^+	2	23.15745	27.33458
Cs	1	3.89390	Cs^+	2	23.15745	27.05135
Ba	1	5.21170	Cs^+	2	23.15745	28.36915
Fr	1	4.0727	Cs^+	2	23.15745	27.23015
Ra	1	5.27892	Cs^+	2	23.15745	28.43637
Ac	1	5.17	Cs^+	2	23.15745	28.32745
$O^{\cdot}$	1	13.61806	O	1	13.61806	27.23612
H	1	13.59844	O	1	13.61806	27.2165
H	1	13.59844	H	1	13.59844	27.19688

Single Electron Transfer (Multiple Species)

A catalysts is provided by the transfer of an electron between participating species including atoms, ions, molecules, and ionic and molecular compounds. In one embodiment, the transfer of an electron from one species to another species provides a net enthalpy of reaction whereby the sum of the ionization energy of the electron donating species minus the ionization energy or electron affinity of the electron accepting species equals approximately $m \, X \, 27.2 \, eV$ where m is an integer.

Single Electron Transfer (Two Species): $m = 1$ in Eq. (2)

One such catalytic system involves calcium and cesium. The third ionization energy of calcium is $50.9131 \, eV$; and Cs^{2+} releases $23.15745 \, eV$ when it is reduced to Cs^+. The combination of reactions Ca^{2+} to Ca^{3+} and Cs^{2+} to Cs^+, then, has a net enthalpy of reaction of $27.75565 \, eV$, which is equivalent to $m = 1$ in Eq. (2).

$$27.75565 \, eV + Ca^{2+} + Cs^{2+} + H\left[\frac{a_H}{p}\right] \rightarrow Cs^+ + Ca^{3+} + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2] \, X \, 13.6 \, eV$$

(21)

3 1

$$Cs^+ + Ca^{3+} \rightarrow Cs^{2+} + Ca^{2+} + 27.75565 \, eV \tag{22}$$

The overall reaction is
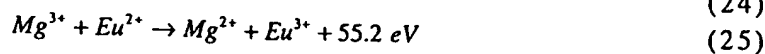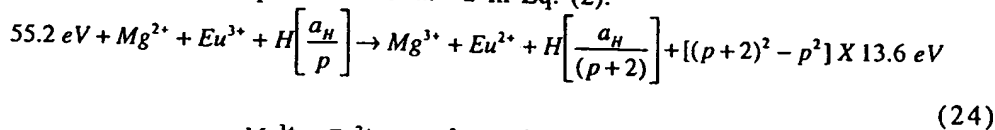
$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2] \, X \, 13.6 \, eV \tag{23}$$

Hydrogen catalysts capable of providing a net enthalpy of reaction
5 of approximately 27.2 eV to produce hydrino whereby an electron is
transferred from one species to a second species are given *infra*. The
atom or ion in the first column is oxidized, and the atom or ion in the
fourth column is reduced to provide the net enthalpy of reaction. The
number in the column following the atom or ion, (n), is the nth ionization
10 energy of the atom or ion. That is for example, $Ca^{2+} + 50.9131 \, eV \rightarrow Ca^{3+} + e^-$
and $Cs^{2+} + e^- \rightarrow Cs^+ + 21.15745 \, eV$. The net enthalpy of reaction for an
electron transfer from Ca^{2+} to Cs^{2+} is 27.76 eV as given in the seventh
column.

Atom or Ion Oxidized	n th Ionization	n th Ionization Energy (eV)	Atom or Ion Reduced	n th Ionization	n th Ionization Energy (eV)	Net Enthalpy of Reaction of Catalyst (eV)
Ca^{2+}	3	50.9131	Cs^{2+}	2	23.15745	27.75565
Mn^{3+}	4	51.2	Cs^{2+}	2	23.15745	28.04
As^{3+}	4	50.13	Cs^{2+}	2	23.15745	26.97255
Nb^{4+}	5	50.55	Cs^{2+}	2	23.15745	27.39255
La^{3+}	4	49.95	Cs^{2+}	2	23.15745	26.79255

15

Single Electron Transfer (Two Species): $m = 2$ in Eq. (2)

One such catalytic system involves magnesium and europium. The
third ionization energy of magnesium is 80.143 eV, and the second
ionization energy of europium is 24.9 eV. The combination of reactions
20 Mg^{2+} to Mg^{3+} and Eu^{3+} to Eu^{2+}, then, has a net enthalpy of reaction of
55.2 eV, which is equivalent to $m = 2$ in Eq. (2).

$$55.2 \, eV + Mg^{2+} + Eu^{3+} + H\left[\frac{a_H}{p}\right] \rightarrow Mg^{3+} + Eu^{2+} + H\left[\frac{a_H}{(p+2)}\right] + [(p+2)^2 - p^2] \, X \, 13.6 \, eV \tag{24}$$

$$Mg^{3+} + Eu^{2+} \rightarrow Mg^{2+} + Eu^{3+} + 55.2 \, eV \tag{25}$$

32

The overall reaction is

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+2)}\right] + [(p+2)^2 - p^2] \, X \, 13.6 \, eV \qquad (26)$$

Hydrogen catalysts capable of providing a net enthalpy of reaction
5   of approximately $54.4 \, eV$ to produce hydrino whereby an electron is
transferred from one ion to another are given *infra*. The atoms or ions in
the first column are oxidized while the atoms or ions in the fourth column
are reduced to provide the net enthalpy of reaction. The number in the
column following the atom or ion, (n), is the nth ionization energy of the
10 atom or ion. That is for example, $Mg^{2+} + 80.143 \, eV \rightarrow Mg^{3+} + e^-$ and
$Eu^{3+} + e^- \rightarrow Eu^{2+} + 24.9 \, eV$. The net enthalpy of reaction for oxidation of Mg^{2+}
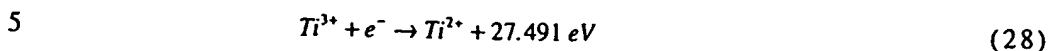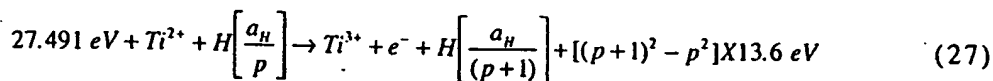and the reduction of Eu^{3+} is $55.2 \, eV$ as given in the seventh column.

Atom or Ion Oxidized	n th Ionization	n th Ionization Energy (eV)	Atom or Ion Reduced	n th Ionization	n th Ionization Energy (eV)	Net Enthalpy of Reaction of Catalyst (eV)
Mg^{2+}	3	80.143	Sc^{3+}	2	27.76	55.38
Mg^{2+}	3	80.143	Nb^{3+}	2	25.04	54.7
Mg^{2+}	3	80.143	Sb^{3+}	2	25.3	54.8
Mg^{2+}	3	80.143	Eu^{3+}	2	24.9	55.2
Mg^{2+}	3	80.143	Yb^{3+}	2	25.03	55.1
Dy^{3+}	4	41.50	Bi^{3+}	2	25.56	54.58

15   Titanium hydrino hydride may be an effective catalyst wherein Ti^{2+}
is the active species. Furthermore, titanium hydrino hydride is volatile
and may serve as a gaseous transition catalyst. Titanium is typically in a
4+ oxidation state. Increased binding energy hydrogen species such as
hydrino hydride ions may stabilize the 2+ oxidation state. Exemplary
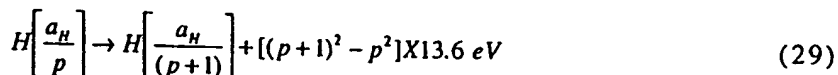20 titanium (II) hydrino hydride compounds are $TiH(1/p)_2$ and

$$TiH(1/p)_2\left(H_2^*\left[2c' = \frac{\sqrt{2}a_0}{p}\right]\right)_2$$ where p is an integer greater than 1, preferably

from 2 to 200. Titanium (II) is a catalyst because the third ionization
energy is $27.49 \, eV$, $m = 1$ in Eq. (2). Thus, the catalysis cascade for the p th
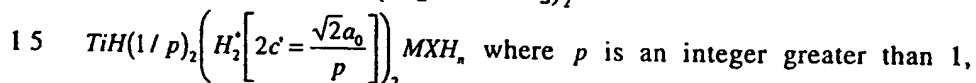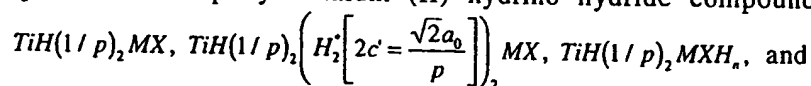
cycle is represented by

$$27.491 \, eV + Ti^{2+} + H\left[\frac{a_H}{p}\right] \rightarrow Ti^{3+} + e^- + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]X13.6 \, eV \qquad (27)$$

$$Ti^{3+} + e^- \rightarrow Ti^{2+} + 27.491 \, eV \qquad (28)$$

And, the overall reaction is

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]X13.6 \, eV \qquad (29)$$

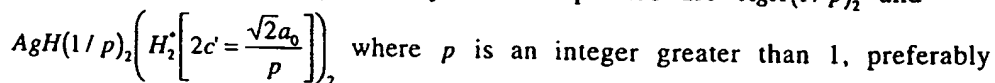where p is an integer greater than 1, preferably from 2 to 200.

Titanium hydrino hydride may be combined with another element to increase the effectiveness of the catalyst when Ti^{2+} is the active species. Exemplary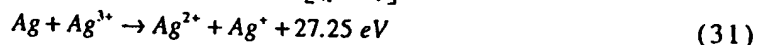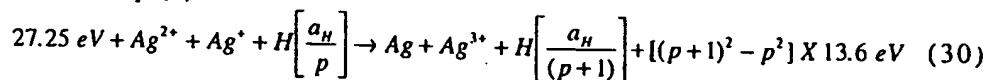 titanium (II) hydrino hydride compounds are $TiH(1/p)_2 MX$, $TiH(1/p)_2 \left(H_2^*\left[2c' = \frac{\sqrt{2}a_0}{p}\right]\right)_2 MX$, $TiH(1/p)_2 MXH_n$, and

$TiH(1/p)_2 \left(H_2^*\left[2c' = \frac{\sqrt{2}a_0}{p}\right]\right)_2 MXH_n$ where p is an integer greater than 1,

preferably from 2 to 200, n is an integer, preferably from 1 to 100, M is an alkaline, alkaline earth, transition metal, inner transition metal, or rare earth cation, X is an anion such as halogen ions, hydroxide ion, hydrogen carbonate ion, nitrate ion, carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H. Preferably, the more effective titanium hydrino hydride catalyst is $TiH(1/p)_2 NiO$ or $TiH(1/p)_2 NiOH_2$.

Silver hydrino hydride may be an effective catalyst wherein Ag^{2+} and Ag^+ are the active species. Furthermore, silver hydrino hydride may be volatile and may serve as a gaseous transition catalyst. Silver is typically in a 1+ oxidation state. Increased binding energy hydrogen species such as hydrino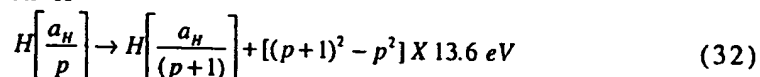 hydride ions may stabilize the 2+ oxidation state. Exemplary silver (II) hydrino hydride compounds are $AgH(1/p)_2$ and

$AgH(1/p)_2 \left(H_2^*\left[2c' = \frac{\sqrt{2}a_0}{p}\right]\right)_2$ where p is an integer greater than 1, preferably

34

from 2 to 200. Silver may be a catalytic system because the third
ionization energy of silver is 34.83 eV; and Ag^+ releases 7.58 eV when it is
reduced to Ag. The combination of reactions Ag^{2+} to Ag^{3+} and Ag^+ to Ag,
then, has a net enthalpy of reaction of 27.25 eV, which is equivalent to
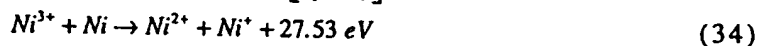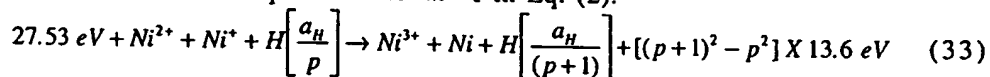$m = 1$ in Eq. (2).

$$27.25 \ eV + Ag^{2+} + Ag^+ + H\left[\frac{a_H}{p}\right] \rightarrow Ag + Ag^{3+} + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2] X \ 13.6 \ eV \quad (30)$$

$$Ag + Ag^{3+} \rightarrow Ag^{2+} + Ag^+ + 27.25 \ eV \quad (31)$$

The overall reaction is

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2] X \ 13.6 \ eV \quad (32)$$
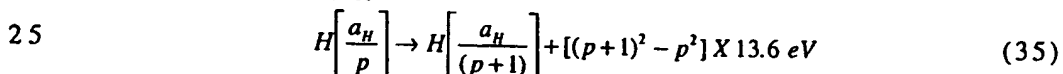
where p is an integer greater than 1, preferably from 2 to 200.

Nickel hydrino hydride may be an effective catalyst wherein Ni^{2+}
and Ni^+ are the active species. Furthermore, nickel hydrino hydride may
be volatile and may serve as a gaseous transition catalyst. Nickel is
typically in a 2+ oxidation state. Increased binding energy hydrogen
species such as hydrino hydride ions may stabilize the 1+ oxidation state.
An exemplary nickel (I) hydrino hydride compounds is $NiH(1/p)$ where p
is an integer greater than 1, preferably from 2 to 200. Nickel may be a
catalytic system because the third ionization energy of nickel is 35.17 eV;
and Ni^+ releases 7.64 eV when it is reduced to Ni. The combination of
reactions Ni^{2+} to Ni^{3+} and Ni^+ to Ni, then, has a net enthalpy of reaction of
27.53 eV, which is equivalent to $m = 1$ in Eq. (2).

$$27.53 \ eV + Ni^{2+} + Ni^+ + H\left[\frac{a_H}{p}\right] \rightarrow Ni^{3+} + Ni + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2] X \ 13.6 \ eV \quad (33)$$

$$Ni^{3+} + Ni \rightarrow Ni^{2+} + Ni^+ + 27.53 \ eV \quad (34)$$

The overall reaction is

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2] X \ 13.6 \ eV \quad (35)$$

where p is an integer greater than 1, preferably from 2 to 200.

In the case that titanium, silver, or nickel metal is present in the
cell and may be used as the dissociator to provide atomic hydrogen, the
titanium, silver, or nickel hydrino hydride catalyst may have an
accelerating catalytic rate wherein the product of catalysis, hydrino, may
react with the titanium, silver, or nickel metal to produce further
titanium, silver, or nickel hydrino hydride catalyst. A method to start the
process is to add a catalyst such as KI, K_2CO_3, RbI, or Rb_2CO_3 to the cell to

35

catalyze the initial formation of titanium, silver, or nickel hydrino hydride. Alternatively, some titanium, silver, or nickel hydrino hydride may be added to the cell or generated by reacting the titanium, silver, or nickel with a source of hydrogen atoms and catalyst such as an aqueous
5   solution of K_2CO_3 and H_2O_2 or an aqueous solution of Rb_2CO_3 and H_2O_2.

An exemplary method to generate a hydrogen catalyst comprising hydrino hydride ions is to treat a titanium hydrogen dissociator with about 0.6 M K_2CO_3/10% H_2O_2 to form the hydrogen catalyst $TiH(1/p)_2$. Titanium hydrino hydride may form by a titanium peroxide intermediate.
10   The potassium ions present may catalyze the formation of hydrinos from hydrogen atoms formed by the decomposition of H_2O_2. The hydrinos may react with titanium to form titanium hydrino hydride. In the case of a gas cell hydrino hydride reactor with KI catalyst, for example, and hydrogen flow, potassium hydrino hydride may form with the loss of
15   iodine from the cell. Potassium hydrino hydride may react with titanium metal to form titanium hydrino hydride and potassium metal. In the case of a K_2CO_3 catalyst, carbon dioxide and oxygen may be lost from the cell with the formation of potassium metal.

A further exemplary method to generate a hydrogen catalyst
20   comprising hydrino hydride ions is to treat a titanium hydrogen dissociator with about 0.6 M Rb_2CO_3/10% H_2O_2 to form the hydrogen catalyst $TiH(1/p)_2$. Titanium hydrino hydride may form by a titanium peroxide intermediate. The rubidium ions present may catalyze the formation of hydrinos from hydrogen atoms formed by the decomposition
25   of H_2O_2. The hydrinos may react with titanium to form titanium hydrino hydride. In the case of a gas cell hydrino hydride reactor with RbI catalyst, for example, and hydrogen flow, rubidium hydrino hydride may form with the loss of iodine from the cell. Rubidium hydrino hydride may react with titanium metal to form titanium hydrino hydride and
30   rubidium metal. In the case of a Rb_2CO_3 catalyst, carbon dioxide and oxygen may be lost from the cell with the formation of rubidium metal.

Cesium metal may catalyze the formation of hydrinos from hydrogen atoms. The hydrinos may react with titanium to form titanium hydrino hydride. For example, in the case of a gas cell hydrino hydride
35   reactor with hydrogen flow and $Cs(m)$ catalyst formed for the decomposition of Cs_2CO_3, cesium hydrino hydride may form with the loss of carbonate from the cell as carbon dioxide and oxygen. Cesium hydrino

hydride may react with titanium metal to form titanium hydrino hydride and large amounts of cesium metal.

In another method to form hydrogen catalyst, titanium hydrino hydride, the formation of titanium hydrino hydride is initiated by the presence of a titanium compound such as a titanium halide (for example $TiCl_4$), $TiTe_2$, $Ti_2(SO_4)_3$, or TiS_2 which may react with an increased binding energy hydrogen species to form titanium hydrino hydride in an operating gas cell hydrino hydride reactor. The increased binding energy hydrogen species may form in the operating hydrino hydride reactor.

Further examples of catalysts providing the catalytic reaction of Eqs. (3-5) is increased binding energy hydrogen compound KH_n where n is an integer from one to 100 and increased binding energy hydrogen compounds KH_nX where n is an integer from one to 100 H may be an increased binding energy hydrogen species and X is a compound such as $KHSO_4$, KHI, $KHCO_3$, $KHNO_3$, HNO_3, KH_2PO_4, or KOH. In another embodiment, rubidium replaces potassium (e.g. $RbHRbHCO_3$ or $RbHRbOH$ are the hydrogen catalysts comprising an increased binding energy hydrogen species such as hydrino hydride ion). The hydrino hydride compounds which are catalysts may be gaseous catalyst by operating a gas cell hydrino hydride reactor at an elevated temperature.

A method to generate a hydrogen catalyst comprising a potassium or rubidium cation, an anion, and at least one increased binding energy hydrogen species such as a hydrino hydride ion is to treat a hydrogen dissociator such as nickel or titanium with an aqueous solution of about 0.6 molar salt comprising at least a potassium or rubidium cation and the anion and 10% H_2O_2 to form the hydrogen catalyst. Alternatively, a first hydrogen catalyst having an anion is used in a hydrino hydride reactor such that the catalyst compound reacts with an increased binding energy hydrogen species to form a second hydrogen catalyst comprising a potassium or rubidium cation, an anion, and at least one increased binding energy hydrogen species such as a hydrino hydride ion. Exemplary anions are OH^-, CO_3^{2-}, HCO_3^-, NO_3^-, SO_4^{2-}, HSO_4^-, PO_4^{3-}, HPO_4^{2-}, and $H_2PO_4^-$. For example, a method to generate a hydrogen catalyst comprising at least one increased binding energy hydrogen species such as a hydrino hydride ion is to treat a hydrogen dissociator such as nickel or titanium with about 0.6 M K_2CO_3/10% H_2O_2 to form a hydrogen catalyst comprising

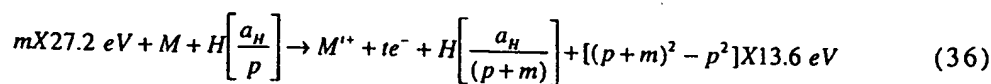potassium and at least one increased binding energy hydrogen species such as $KHKHCO_3$ or $KHKOH$.

In an embodiment, the catalyst Rb^+ according to Eqs. (6-8) may be formed from rubidium metal by ionization. The source of ionization may be UV light or a plasma. At least one of a source of UV light and a plasma may be provided by the catalysis of hydrogen with a one or more hydrogen catalysts such as potassium metal or K^+ ions.

In an embodiment, the catalyst K^+/K^+ according to Eqs. (3-5) may be formed from potassium metal by ionization. The source of ionization may be UV light or a plasma. At least one of a source of UV light and a plasma may be provided by the catalysis of hydrogen with a one or more hydrogen catalysts such as potassium metal or K^+ ions.

In an embodiment, the catalyst Rb^+ according to Eqs. (6-8) or the catalyst K^+/K^+ according to Eqs. (3-5) may be formed by reaction of rubidium metal or potassium metal, respectively, with hydrogen to form the corresponding alkali hydride or by ionization at a hot filament which may also serve to dissociate molecular hydrogen to atomic hydrogen. The hot filament may be a refractory metal such as tungsten or molybdenum operated within a high temperature range such as 1000 to 2800 °C.

In an embodiment of the hydrino hydride reactor, a catalyst is selected such that a desired increased binding energy hydrogen species such as one selected from the group consisting of hydrino atom having a binding energy given by Eq. (1), a dihydrino molecule having a binding energy of about $\dfrac{15.5}{\left(\dfrac{1}{p}\right)^2}\ eV$, and hydrino hydride ion having a binding energy given by Eq. (10) is formed. The catalyst may be selected such that it has a desired enthalpy of reaction of about $m\,X\,27.2\ eV$ where m is an integer to provide a selected catalysis of hydrogen. For example, the sum of the ionization energies of t electrons from an atom M to form M^{t+} is about $m\,X\,27.2\ eV$. Thus, the catalysis cascade for the p th cycle is represented by

$$mX27.2\ eV + M + H\left[\frac{a_H}{p}\right] \rightarrow M^{t+} + te^- + H\left[\frac{a_H}{(p+m)}\right] + [(p+m)^2 - p^2]X13.6\ eV \qquad (36)$$

$$M^{t+} + te^- \rightarrow M + 27.2\ eV \qquad (37)$$

The overall reaction is

38

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+m)}\right] + [(p+m)^2 - p^2] X 13.6 \, eV \qquad (38)$$

where p is an integer greater than 1, preferably from 2 to 200. The desired hydrino product may further react to form a desired increased binding energy hydrogen species or increased binding energy hydrogen compound.

It is believed that the rate of catalysis is increased as the net enthalpy of reaction is more closely matched to $m \cdot 27.2 \, eV$ where m is an integer. An embodiment of the hydrino hydride reactor for producing increased binding energy hydrogen compounds of the invention further comprises an electric or magnetic field source. The electric or magnetic field source may be adjustable to control the rate of catalysis. Adjustment of the electric or magnetic field provided by the electric or magnetic field source may alter the continuum energy level of a catalyst whereby one or more electrons are ionized to a continuum energy level to provide a net enthalpy of reaction of approximately $m \, X \, 27.2 \, eV$. The alteration of the continuum energy may cause the net enthalpy of reaction of the catalyst to more closely match $m \cdot 27.2 \, eV$. Preferably, the electric field is within the range of $0.01 - 10^6 \, V/m$, more preferably $0.1 - 10^4 \, V/m$, and most preferably $1 - 10^3 \, V/m$. Preferably, the magnetic flux is within the range of $0.01 - 50 \, T$. A magnetic field may have a strong gradient. Preferably, the magnetic flux gradient is within the range of $10^{-4} - 10^2 \, Tcm^{-1}$ and more preferably $10^{-3} - 1 \, Tcm^{-1}$.

For example, the cell may comprise a hot filament that dissociates molecular hydrogen to atomic hydrogen and may further heat a hydrogen dissociator such as transition elements and inner transition elements, iron, platinum, palladium, zirconium, vanadium, nickel, titanium, Sc, Cr, Mn, Co, Cu, Zn, Y, Nb, Mo, Tc, Ru, Rh, Ag, Cd, La, Hf, Ta, W, Re, Os, Ir, Au, Hg, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Vb, Lu, Th, Pa, U, activated charcoal (carbon), and intercalated Cs carbon (graphite). The filament may further supply an electric field in the cell of the reactor. The electric field may alter the continuum energy level of a catalyst whereby one or more electrons are ionized to a continuum energy level to provide a net enthalpy of reaction of approximately $m \, X \, 27.2 \, eV$. In another embodiment, an electric field is provided by electrodes charged by a variable voltage source. The rate of catalysis may be controlled by

39

controlling the applied voltage which determines the applied field which controls the catalysis rate by altering the continuum energy level.

In another embodiment of the hydrino hydride reactor, the electric or magnetic field source ionizes an atom or ion to provide a catalyst
5   having a net enthalpy of reaction of approximately $mX\,27.2\,eV$. For examples, potassium metal is ionized to K^+, or rubidium metal is ionized to Rb^+ to provide the catalysts according to Eqs. (3-5) or Eqs. (6-8), respectively. The electric field source may be a hot filament whereby the hot filament may also dissociate molecular hydrogen to atomic hydrogen.
10 In the case that the hydrino hydride reactor comprises multiple catalysts that are selected to form one or more desired increased binding energy hydrogen species or increased binding energy hydrogen compounds, the electric or magnetic field provided by the electric or magnetic field source may be adjusted to preferentially increase the
15 catalysis rate for one or more of the selected catalysts relative to one or more nonselected catalysts. Thus, the relative yield of one or more desired increased binding energy hydrogen species or increased binding energy hydrogen compounds may be adjusted.

An further embodiment of the hydrino hydride reactor further
20 comprises a source of thermal electrons. The source of electrons may reduce and thereby regenerate a catalyst whereby one or more electrons are ionized to a continuum energy level to provide a net enthalpy of reaction of approximately $mX\,27.2\,eV$. A hot filament may be a source of thermal electrons. The hot filament may further comprise one or more of
25 the elements selected from the group of a hydrogen dissociator, a catalyst heater, a hydrogen dissociator heater, a cell heater, and a source of electric field.
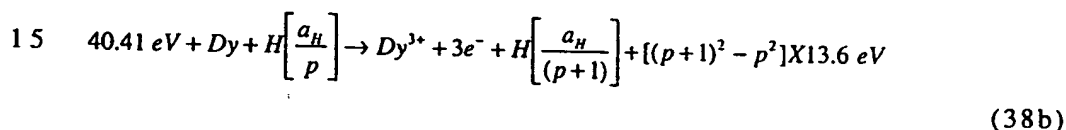
In another embodiment of the catalyst of the present invention, hydrinos are formed by reacting an ordinary hydrogen atom with a
30 catalyst having a net enthalpy of reaction of about
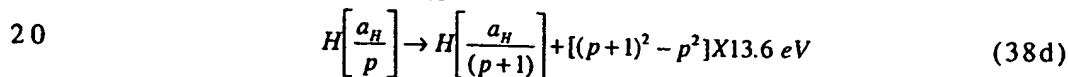
$$\frac{m}{2}\cdot 27.2\,eV \tag{38a}$$

where m is an integer. It is believed that the rate of catalysis is increased as the net enthalpy of reaction is more closely matched to $\frac{m}{2}\cdot 27.2\,eV$. It has been found that catalysts having a net enthalpy of reaction within
35 $\pm 10\%$, preferably $\pm 5\%$, of $\frac{m}{2}\cdot 27.2\,eV$ are suitable for most applications.

t Electron Transfer (One Species)

In another embodiment, a catalytic system is provided by the ionization of t electrons from a participating species such as an atom, an ion, a molecule, and an ionic or molecular compound to a continuum energy level such that the sum of the ionization energies of the t electrons is approximately $\frac{m}{2} \cdot 27.2 \, eV$ where m is an integer. One such catalytic system involves dysprosium. The first, second, and third ionization energies of dysprosium are $5.9389 \, eV$, $11.67 \, eV$, and $22.8 \, eV$, respectively [David R. Linde, CRC Handbook of Chemistry and Physics, 78 th Edition, CRC Press, Boca Raton, Florida, (1997), pp. 10-214-10-216]. The three ionization ($t = 3$) reaction of Dy to Dy^{3+}, then, has a net enthalpy of reaction of $40.41 \, eV$, which is equivalent to $m = 3$ in Eq. 38a.

$$40.41 \, eV + Dy + H\left[\frac{a_H}{p}\right] \rightarrow Dy^{3+} + 3e^- + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]X13.6 \, eV$$

(38b)

$$Dy^{3+} + 3e^- \rightarrow Dy + 40.41 \, eV \tag{38c}$$

And, the overall reaction is

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]X13.6 \, eV \tag{38d}$$

Hydrogen catalysts capable of providing a net enthalpy of reaction of approximately $\frac{m}{2} \cdot 27.2 \, eV$ where m is an integer to produce hydrino whereby t electrons are ionized from an atom or ion are given *infra*. The atoms or ions given in the first column are ionized to provide the net enthalpy of reaction of $\frac{m}{2} \cdot 27.2 \, eV$ given in the tenth column where m is given in the eleventh column. The electrons which are ionized are given with the ionization potential (also called ionization energy or binding energy). The ionization potential of the nth electron of the atom or ion is designated by IP_n and is given by David R. Linde, CRC Handbook of Chemistry and Physics, 78 th Edition, CRC Press, Boca Raton, Florida, (1997), pp. 10-214-10-216 which is herein incorporated by reference. That is for example, $Dy + 5.9389 \, eV \rightarrow Dy^+ + e^-$, $Dy^+ + 11.67 \, eV \rightarrow Dy^{2+} + e^-$ and $Dy^{2+} + 22.8 \, eV \rightarrow Dy^{3+} + e^-$. The first ionization potential, $IP_1 = 5.9389 \, eV$, the
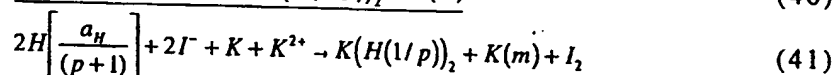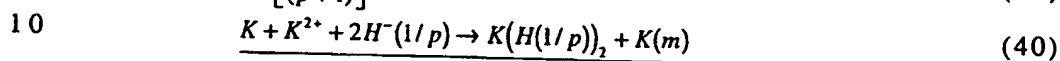
second ionization potential, $IP_2 = 11.67\,eV$, and the third ionization potential, $IP_3 = 22.8\,eV$, are given in the second, third, and fourth columns, respectively. The net enthalpy of reaction for the triple ionization of Dy is $40.409\,eV$ as given in the tenth column, and $m = 3$ in Eq. (38a) as given in the eleventh column.

Catalyst	IP1	IP2	IP3	IP4	IP5	IP6	IP7	IP8	Enthalpy	m
Li	5.392	75.64							81.032	6
K	4.341	31.63	45.81						81.777	6
V	6.746	14.66	29.31	46.71	65.28				162.71	12
Cr	6.767	16.49	30.96						54.212	4
Se	9.752	21.19	30.82	42.95	68.3	81.7	155.4		410.11	30
Mo	7.092	16.16	27.13	46.4	54.49	68.83	125.7	143.6	489.36	36
Sn	7.344	14.63	30.5	40.74	72.28				165.49	12
Sm	5.644	11.07	23.4	41.4					81.514	6
Gd	6.15	12.09	20.63	44					82.87	6
Dy	5.939	11.67	22.8	41.47					81.879	6
Dy	5.939	11.67	22.8						40.409	3
Ho	6.022	11.8	22.84						40.662	3
Er	6.108	11.93	22.74						40.778	3
Lu	5.426	13.9	20.96						40.285	3

A process of the present invention is the formation of a metal such as potassium metal, rubidium metal, or cesium metal by the reduction of K^+, Rb^+, or Cs^+, respectively, via the catalysis of hydrogen to form increased binding energy hydrogen compounds and the metal. Other metals such as lithium or sodium may be made by reacting potassium, rubidium, or cesium metal with a lithium or sodium compound, respectively. Techniques commonly used by those skilled in the art can be used in a similar manner to form and isolate other metals by reacting potassium, rubidium, or cesium metal with an alkali compound. The reaction may occur continuously in the hydrino hydride reactor. For example, a hydrogen catalyst such as K_2CO_3 may be added to a gas cell hydrino hydride reactor containing an alkali compound such as Na_2CO_3 or Li_2CO_3. Catalysis of hydrogen produces hydrino hydride compounds and potassium metal. Potassium metal is more active than lithium or sodium metal. Thus, the potassium metal reacts with Na_2CO_3 or Li_2CO_3 to form K_2CO_3 and lithium or sodium metal, respectively. In one embodiment, the alkali compound that is not a hydrogen catalyst is present in a molar excess. In another embodiment, other elements or compounds of other elements present in the hydrino hydride reactor such as alkaline earth,

42

transition metal, rare earth, and precious metal compounds are reduced by an alkaline metal formed in the hydrino hydride reactor.

In the case that the catalyst is reduced to a metal during catalysis, the metal may accumulate in the reactor such as a gas cell hydrino
5   hydride reactor during operation. Hydrino hydride compounds having a cation in a high oxidation state may form. For example, the potassium catalysis reaction is given by Eqs. (3-5). A potassium metal forming reaction is:

$$2H\left[\frac{a_H}{(p+1)}\right]+2I^- \rightarrow I_2 + 2H^-(1/p) \tag{39}$$

10

$$K + K^{2+} + 2H^-(1/p) \rightarrow K\big(H(1/p)\big)_2 + K(m) \tag{40}$$

$$2H\left[\frac{a_H}{(p+1)}\right]+2I^- + K + K^{2+} \rightarrow K\big(H(1/p)\big)_2 + K(m) + I_2 \tag{41}$$

Potassium metal may accumulate in the cell as I_2 is pumped from the cell. The potassium metal may form an amalgam with the dissociator which inhibits hydrogen dissociation. Thus, I_2 or HI may be supplied to the cell
15   to regenerate the catalyst KI and regenerate the dissociator.
Alternatively, other oxidants such as water, oxygen, or an oxyanion may be supplied to the gas cell hydrino hydride reactor to react with the alkali metal.

Hydrogen polymers such as H_{16} may be synthesized from increased
20   binding energy hydrogen compounds by polymerization. Increased binding energy hydrogen compounds may be reacted with polymerizing agents such as oxidizing agents, reductants, or free radical generating agents to form polymers. Increased binding energy hydrogen species of increased binding energy hydrogen compounds may also be polymerized
25   by reacting with one or more of the polymerizing agents. Examples of suitable polymerize agents include nitric acid, hydro iodic acid, sulfuric acid, hydro fluoric acid, hydrochloric acid, potassium metal, and a mixture of base and hydrogen peroxide such as K_2CO_3/ H_2O_2. Hydrogen polymers may also form during catalysis in the electrolytic cell, gas cell, gas
30   discharge cell, or plasma torch cell hydrino hydride reactor. In one embodiment, hydrogen polymers such as H_{16} may be synthesized from hydrogen in a gas cell or gas discharge cell wherein the source of catalyst is potassium metal. Hydrogen polymer compounds may be purified from the reaction mixture by the methods given in the Purification of

43

Increased Binding Energy Hydrogen Compounds section of my previous PCT Patent Application, PCT US98/14029 filed on July 7, 1998, which is incorporated herein by reference.

Hydrogen polymers such as H_{16} may also be synthesized from
5   increased binding energy hydrogen compounds by polymerization at high temperature. In one embodiment, an increased binding energy hydrogen compound such as potassium hydrino hydride or titanium hydrino hydride is formed as an intermediate that is polymerized at high temperature in a high temperature reactor. Examples of suitable
10   temperatures are within the range of about 500 °C to about 2800 °C. For example, if the increased binding energy hydrogen compounds are formed in a gas cell hydrino hydride reactor at one temperature, such a temperature within the range of about 350 °C to about 800 °C, the increased binding energy hydrogen compounds may polymerized in the
15   gas cell hydrino hydrided reactor by elevating the reactor temperature to range within about 850 °C to about 2800 °C. In an embodiment, the polymerization may be catalyzed by a hot metal surface such as that of a hot refractory metal filament. For example, a gas cell hydrino hydride reactor may comprise a hot tungsten filament maintained at an elevated
20   temperature such as a temperature within the range 1200 °C to 2800 °C wherein hydrogen catalysis occurs to form increased binding energy hydrogen species which polymerize on contact with the hot filament. Based on the disclosure herein, one skilled in the art will be able to select a suitable polymerization temperature to form the desired increased
25   binding energy hydrogen polymer.

Hydrino hydride compounds have been found to be stable to electrolysis at a voltage that is substantially greater than that of ordinary compounds. Hydrino hydride compounds such as potassium hydrino hydride may be purified by electrolysis at a sufficiently high voltage that
30   the anion of the catalyst is oxidized. In one embodiment, the reaction products of the hydrino hydride reactor are collected and run in a molten electrolytic cell such that the reduced cation of the catalyst such as potassium metal forms at the cathode, and the oxidized anion of the catalyst such as halogen gas (for example I_2) forms at the anode. The
35   electrolyzed catalyst products such as iodine gas and potassium metal are separated from the hydrino hydride compounds that are stable to

44

electrolysis. Methods of separation such as distillation and phase separation techniques commonly used by those skilled in the art can be used in a similar manner to isolate hydrino hydride compounds. For example, iodine can be removed at low temperatures as a gas, and

5   potassium metal can be removed with the cathode onto which it electroplates.

A method of isotope separation comprises the step of reacting an element or compound having an isotopic mixture containing the desired element with an increased binding energy hydrogen species in atomic

10 percent shortage based on the stoichiometric amount to fully react with or bond to the desired isotope. The increased binding energy hydrogen species is selected such that the bond energy of the reaction product is dependent on the isotope of the desired element. Thus, an increased binding energy species can be selected such that the predominant

15 reaction product contains at least one increased binding energy hydrogen species bound to the desired isotope. The compound comprising at least one increased binding energy hydrogen species and the desired isotope can be separated from the reaction mixture. The increased binding energy hydrogen species may be separated from the desired isotope to

20 obtain the desired isotope. The recovered isotope may be reacted with the increased binding energy hydrogen species and these steps may be repeated to obtain a desired level of enrichment. The use of the term "isotope" in this context includes an individual element as well as compounds containing the desired elemental isotope.

25   Another method of isotope separation comprises the step of reacting an element or compound having an isotopic mixture containing the desired element with an increased binding energy hydrogen species that bonds to the undesired isotope. Since the bond energy of the reaction product is dependent on the isotope of the undesired element,

30 an increased binding energy species can be selected such that the predominant reaction product contains at least one increased binding energy hydrogen species bound to the undesired isotope, and the desired isotope remains substantially unbound. The compound comprising at least one increased binding energy hydrogen species and the undesired

35 isotope can be separated from the reaction mixture to obtain the desired isotope. The use of the term "isotope" in this context includes an individual element as well as compounds containing the desired

45

elemental isotope.

A further method of separating a desired isotope from a mixture of isotopes comprises:

5   reacting an increased binding energy hydrogen species with an isotopic mixture comprising a molar excess of a desired isotope with respect to the increased binding energy hydrogen species to form a compound enriched in the desired isotope;

separating said compound enriched in the desired isotope from the reaction mixture; and

10   separating the increased binding energy hydrogen species from the desired isotope to obtain the desired isotope.

Another method of separating a desired isotope from a mixture of isotopes comprises:

reacting a mixture of isotopes with an amount of an increased

15   binding energy hydrogen species sufficient to remove an undesired isotope from a isotopic mixture to form a compound enriched in the undesired isotope, and

removing said compound enriched in the undesired isotope.

The mixture of isotopes can comprise elements and/or compounds

20   containing the isotopes.

Other objects, features, and characteristics of the present invention, as well as the methods of operation and the functions of the related elements, will become apparent upon consideration of the following description and the appended claims with reference to the accompanying

25   drawings, all of which form a part of this specification, wherein like reference numerals designate corresponding parts in the various figures.

III. BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a schematic drawing of an electrolytic cell hydride reactor

30   in accordance with the present invention;

FIGURE 2 is a schematic drawing of an experimental quartz gas cell hydride reactor in accordance with the present invention;

FIGURE 3 is a schematic drawing of an experimental concentric quartz tubes gas cell hydride reactor in accordance with the present invention;

35   FIGURE 4 is a schematic drawing of an experimental stainless steel gas cell hydride reactor in accordance with the present invention;

Figure 96A is the positive ToF-SIMS spectrum ($m/e = 0 - 50$) of 99.999%

46

KHCO₃ (HC = hydrocarbon);

Figure 96B is the positive ToF-SIMS spectrum ($m/e = 50 - 100$) of 99.999% *KHCO₃* (HC = hydrocarbon);

Figure 96C is the positive ToF-SIMS spectrum ($m/e = 100 - 150$) of 99.999% *KHCO₃* (HC = hydrocarbon);

Figure 96D is the positive ToF-SIMS spectrum ($m/e = 150 - 200$) of 99.999% *KHCO₃* (HC = hydrocarbon);

Figure 97A is the positive ToF-SIMS spectrum ($m/e = 200 - 300$) of 99.999% *KHCO₃* (HC = hydrocarbon);

Figure 97B is the positive ToF-SIMS spectrum ($m/e = 300 - 400$) of 99.999% *KHCO₃* (HC = hydrocarbon);

Figure 97C is the positive ToF-SIMS spectrum ($m/e = 400 - 500$) of 99.999% *KHCO₃* (HC = hydrocarbon);

Figure 97D is the positive ToF-SIMS spectrum ($m/e = 500 - 1000$) of 99.999% *KHCO₃* (HC = hydrocarbon);

Figure 98A is the positive ToF-SIMS spectrum ($m/e = 0 - 50$) of an electrolytic cell sample where HC = hydrocarbon;

Figure 98B is the positive ToF-SIMS spectrum ($m/e = 50 - 100$) of an electrolytic cell sample where HC = hydrocarbon;

Figure 98C is the positive ToF-SIMS spectrum ($m/e = 100 - 150$) of an electrolytic cell sample where HC = hydrocarbon;

Figure 98D is the positive ToF-SIMS spectrum ($m/e = 150 - 200$) of an electrolytic cell sample where HC = hydrocarbon;

Figure 99A is the positive ToF-SIMS spectrum ($m/e = 200 - 300$) of an electrolytic cell sample where HC = hydrocarbon;

Figure 99B is the positive ToF-SIMS spectrum ($m/e = 300 - 400$) of an electrolytic cell sample where HC = hydrocarbon;

Figure 99C is the positive ToF-SIMS spectrum ($m/e = 400 - 500$) of an electrolytic cell sample where HC = hydrocarbon;

Figure 99D is the positive ToF-SIMS spectrum ($m/e = 500 - 1000$) of an electrolytic cell sample where HC = hydrocarbon;

Figure 100 is the 0 to 80 eV binding energy region of a high resolution XPS spectrum of an electrolytic cell sample;

Figure 101 is the XPS survey spectrum an electrolytic cell sample with the primary elements identified;

Figure 102 is the magic angle spinning proton NMR spectrum of an electrolytic cell sample;

47

Figure 103 is the overlap FTIR spectrum an electrolytic cell sample and the FTIR spectrum of the reference potassium carbonate;

Figure 104 is the stainless steel gas cell comprising a Ti screen dissociator, potassium metal catalyst, and KI as the reactant;

5   Figure 105A is the positive ToF-SIMS spectrum ($m/e = 0-50$) of the blue crystals;

Figure 105B is the positive ToF-SIMS spectrum ($m/e = 50-100$) of the blue crystals;

Figure 105C is the positive ToF-SIMS spectrum ($m/e = 100-150$) of the
10   blue crystals;

Figure 105D is the positive ToF-SIMS spectrum ($m/e = 150-200$) of the blue crystals;

Figure 106A is the negative ToF-SIMS spectrum ($m/e = 0-50$) of the blue crystals;

15   Figure 106B is the negative ToF-SIMS spectrum ($m/e = 50-100$) of the blue crystals;

Figure 106C is the negative ToF-SIMS spectrum ($m/e = 100-150$) of the blue crystals;

Figure 106D is the negative ToF-SIMS spectrum ($m/e = 150-200$) of the
20   blue crystals;

Figure 107 is the XPS survey scan of the blue crystals;

Figure 108 is the 0-100 eV binding energy region of a high resolution XPS spectrum of the blue crystals;

Figure 109 is the 0-100 eV binding energy region of a high resolution
25   XPS spectrum of the control KI;

Figure 110 is the ^1H MAS NMR spectrum of the control KH relative to external tetramethylsilane (TMS);

Figure 111 is the ^1H MAS NMR spectra of the blue crystals relative to external tetramethylsilane (TMS);

30   Figure 112 is the ^1H NMR spectrum of the blue crystals exposed to air for 1 minute;

Figure 113 is the ^1H NMR spectrum of the blue crystals exposed to air for 20 minutes;

Figure 114 is the ^1H NMR spectrum of the blue crystals exposed to air
35   for 40 minutes;

Figure 115 is the ^1H NMR spectrum of the blue crystals exposed to air for 60 minutes;

Figure 116 is the FTIR spectra ($500-4000\ cm^{-1}$) of the blue crystals;

Figure 117 is the FTIR spectra ($500-1500\ cm^{-1}$) of the blue crystals;

Figure 118 is the results of the Selected Ion Monitoring LC/MS analysis of the blue crystals wherein the mass spectrum comprised the $m/z=204.6$ ion signal;

Figure 119 is the results of the Selected Ion Monitoring LC/MS analysis of the blue crystals wherein the mass spectrum comprised the $m/z=307.6$ ion signal;

Figure 120 is the gas chromatograph of the dihydrino or hydrogen released from the blue crystals when the sample was heated to above 600 °C with melting;

Figure 121 is the intensity as a function of time for masses $m/e=1$, $m/e=2$, and $m/e=3$ obtained while changing the ionization potential (IP) of the mass spectrometer from 30 eV to 70 eV for gas released from thermal decomposition of the blue crystals, and

Figure 122 is the intensity as a function of time for masses $m/e=1$, $m/e=2$, and $m/e=3$ obtained while changing the ionization potential (IP) of the mass spectrometer from 30 eV to 70 eV for ultrapure hydrogen.

IV. DETAILED DESCRIPTION OF THE INVENTION

Formation of a hydrino hydride ion allows for formation of alkali and alkaline earth hydrides having enhanced stability or reduced reactivity in water. Increased binding energy hydrogen species are capable of forming very strong bonds with certain cations and have unique properties with many applications such as cutting materials (as a replacement for diamond, for example); structural materials and synthetic fibers such as novel inorganic polymers. Due to the small mass of the hydrino hydride ion, these materials can be made significantly lighter in weight than present materials containing conventional anions.

Increased binding energy hydrogen species have many additional applications such as cathodes for thermionic generators; formation of photoluminescent compounds (for example Zintl phase silicides and silanes containing increased binding energy hydrogen species); corrosion resistant coatings; heat resistant coatings; phosphors for lighting; optical coatings; optical filters (for example, due to the unique continuum emission and absorption bands of the increased binding energy hydrogen

species); extreme ultraviolet laser media (for example, as a compound with a with highly positively charged cation); fiber optic cables (for example, as a material with a low attenuation for electromagnetic radiation and a high refractive index); magnets and magnetic computer

5 storage media (for example, as a compound with a ferromagnetic cation such as iron, nickel, or chromium); chemical synthetic processing methods; and refining methods. The specific p hydrino hydride ion ($H^-(n=1/p)$ where p is an integer) may be selected to provide the desired property such as voltage following doping with the hydrino hydride ion.

10 Increased binding energy hydrogen species are useful in mining and refining methods to extract and/or purify a desired element. Increased binding energy hydrogen species may be formulated which are capable of selectively reacting with an element, such as silver, platinum, or gold, of a mixture of elements and/or compounds to form an increased

15 binding energy hydrogen compound containing the desired element. In the case of silver, an exemplary increased binding energy hydrogen compound is $AgHX$ where X is a halogen and H is an increased binding energy hydrogen species. The mixture may be placed in the reaction vessel of the hydrino hydride reactor under conditions such that the

20 reaction of an increased binding energy hydrogen species with the desired element occurs within the reactor. The product may be readily separated from the mixture based on properties of the increased binding energy hydrogen compound using conventional separation methods, such as volatility or solubility. The specific p hydrino hydride ion ($H^-(n=1/p)$

25 where p is an integer) may be selected to provide a desired property of the compound which allows for the extraction or separation of the desired element from the mixture. The compound can be purified from the mixture by the methods disclosed in the Purification of Increased Binding Energy Hydrogen Compounds section of my previous PCT Patent

30 Application, PCT US98/14029 filed on July 7, 1998, which is incorporated herein by reference. The desired element can be isolated by decomposition of the increased binding energy hydrogen compound by methods such as thermal or chemical decomposition.

The reactions resulting in the formation of the increased binding

35 energy hydrogen compounds are useful in chemical etching processes, such as semiconductor etching to form computer chips, for example. Hydrino hydride ions are useful as dopants for semiconductors, to alter

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the energies of the conduction and valance bands of the semiconductor materials. Hydrino hydride ions may be incorporated into semiconductor materials by ion implantation, beam epitaxy, or vacuum deposition. The specific p hydrino hydride ion ($H^-(n=1/p)$ where p is an integer) may be

5   selected to provide a desired property such as band gap following doping.

Due to the high energy released in the formation of a hydrino hydride ion from a hydrino, the hydrino may be a useful etching agent. Hydrinos may be generated such that they collide with the surface to be etched under conditions such that the surface species are oxidized.

10 Increased binding energy hydrogen compounds may provide hydrinos. The hydrinos may be supplied to the surface by thermally or chemically decomposing increased binding energy hydrogen compounds. Alternatively, the source of hydrinos may be an electrolytic cell, gas cell, gas discharge cell, or plasma torch cell hydrino hydride reactor of the

15 present invention. To contact hydrinos with the surface to be etched, the object having the surface may be placed in the hydrino hydride reactor, for example. Alternatively, hydrinos may be applied as an atomic beam by methods known to those skilled in the art.

Hydrino hydride compounds can be formulated for use as

20 semiconductor masking agents. Hydrino species-terminated (versus normal hydrogen-terminated) silicon may be utilized. In one embodiment hydrino species-terminated (versus hydrogen-terminated) silicon is synthesized by exposure of silicon or a silicon compound such as silicon dioxide to hydrinos. Increased binding energy hydrogen

25 compounds may provide hydrinos. The hydrinos may be supplied to the surface by thermally or chemically decomposing increased binding energy hydrogen compounds. Alternatively, the source of hydrinos may be an electrolytic cell, gas cell, gas discharge cell, or plasma torch cell hydrino hydride reactor of the present invention. To contact hydrinos

30 with the silicon reactant, the silicon may be placed in the hydrino hydride reactor, for example. Alternatively, hydrinos may be applied as an atomic beam by methods known to those skilled in the art.

Increased binding energy hydrogen silanes that are stable in air and/or are stable at elevated temperatures are useful sources of pure

35 silicon which may be obtained by decomposition of purified increased binding energy hydrogen silanes. For example, the decomposition to pure silicon may be chemical or thermal.

51

Due to the extraordinary binding energy of increased binding energy hydrogen species such as hydrino hydride ions, increased binding energy hydrogen compounds may contain protons. Thus, increased binding energy hydrogen compounds may be a source of protons. One

5   method to release protons is thermal decomposition of the increased binding energy hydrogen compounds, preferably in vacuum.

The highly stable hydrino hydride ion has application as the negative ion of the electrolyte of a high voltage electrolytic cell. In a further application, a hydrino hydride ion with extreme stability

10 represents a significant improvement as the product of a cathode half reaction of a fuel cell or battery over conventional cathode products of present batteries and fuel cells. The hydrino hydride reaction of Eq. (11) releases significantly more energy than oxidants used in conventional batteries.

15   A further advanced battery application of hydrino hydride ions is in the fabrication of batteries. A battery comprising, as an oxidant compound, a hydrino hydride compound formed of a highly oxidized cation and a hydrino hydride ion ("hydrino hydride battery"), has a lighter weight, higher voltage, higher power, and greater energy density

20 than a conventional battery having a cell voltage of about one volt. In one embodiment, a hydrino hydride battery has a cell voltage of about 100 times that of conventional batteries. The hydrino hydride battery also has a lower resistance than conventional batteries. Thus, the power of the novel battery can be more than 10,000 times the power of

25 conventional batteries. Furthermore, a hydrino hydride battery can be formulated which posses energy densities of greater than 100,000 watt hours per kilogram. In contrast, the most advanced of conventional batteries have energy densities of less that 200 watt hours per kilogram.

The present battery may further comprise an electronic activation

30 circuit which is activated by a user specific input signal called a "password" or "key" such as a swipe card signal. Or the battery may be activated by a signal transmitted to the battery from an electricity supplier such as an electric utility company which permits the battery to be charged. In the latter case, the battery may further comprise an

35 electronic device such as a computer chip which may be installed by the electricity supplier. The signal which activates the battery to be charged may be transmitted to the battery through electrical leads of the charger

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for example. The activation may signal a debit to the electricity consumer based on the electricity consumed during battery charging.

The catalysis of hydrogen by catalysts such as potassium ions (Eqs. 3-5)) and rubidium (Eqs. 6-8)) to form hydrino atoms and hydrino

5 hydride ions may result in the emission of extreme ultraviolet (EUV) photons such as $912\,\mathring{A}$ and $304\,\mathring{A}$. Extreme UV photons may ionize or excite molecular hydrogen resulting in molecular hydrogen emission which includes well characterized ultraviolet lines such as the Balmer series. The hydrogen emission or the hydrogen emission further converted to other

10 wavelengths· using a phosphor, for example, is a lighting source of the present invention. The light source may produce wavelengths such as extreme ultraviolet, ultraviolet, visible, and infrared wavelengths.

Due to the rapid kinetics and the extraordinary exothermic nature of the reactions of increased binding energy hydrogen compounds,

15 particularly hydrino hydride compounds, other applications include munitions, explosives, propellants, and solid fuels.

The selectivity of hydrino atoms and hydride ions in forming bonds with specific isotopes based on a differential in bond energy provides a means to purify desired isotopes of elements.

20 Hydrogen polymers and inorganic hydrogen polymers comprising increased binding energy hydrogen species may be useful as superconductors having a high transition temperature.

1. HYDRIDE ION

25 A hydrino atom $H\left[\dfrac{a_H}{p}\right]$ reacts with an electron to form a

corresponding hydrino hydride ion $H^-(n=1/p)$ as given by Eq. (11). Hydride ions are a special case of two-electron atoms each comprising a nucleus and an "electron 1" and an "electron 2". The derivation of the binding energies of two-electron atoms is given by the '99 Mills GUT. A

30 brief summary of the hydride binding energy derivation follows whereby the equation numbers of the format (#.###) correspond to those given in the '99 Mills GUT.

The hydride ion comprises two indistinguishable electrons bound to

35 a proton of $Z=+1$. Each electron experiences a centrifugal force, and the balancing centripetal force (on each electron) is produced by the electric

5 3

force between the electron and the nucleus. In addition, a magnetic force exists between the two electrons causing the electrons to pair.

1.1 Determination of the Orbitsphere Radius, r_n

5   Consider the binding of a second electron to a hydrogen atom to form a hydride ion. The second electron experiences no central electric force because the electric field is zero outside of the radius of the first electron. However, the second electron experiences a magnetic force due to electron 1 causing it to spin pair with electron 1. Thus, electron 1

10 experiences the reaction force of electron 2 which acts as a centrifugal force. The force balance equation can be determined by equating the total forces acting on the two bound electrons taken together. The force balance equation for the paired electron orbitsphere is obtained by equating the forces on the mass and charge densities. The centrifugal

15 force of both electrons is given by Eq. (7.1) and Eq. (7.2) where the mass is $2m_e$. Electric field lines end on charge. Since both electrons are paired at the same radius, the number of field lines ending on the charge density of electron 1 equals the number that end on the charge density of electron 2. The electric force is proportional to the number of field lines;

20 thus, the centripetal electric force, F_{ele}, between the electrons and the nucleus is represented by

$$F_{ele(electron\ 1,2)} = \frac{\frac{1}{2}e^2}{4\pi\varepsilon_o r_n^2} \tag{42}$$

where ε_o is the permittivity of free-space. The outward magnetic force on the two paired electrons is given by the negative of Eq. (7.15) where

25 the mass is $2m_e$. The outward centrifugal force and magnetic forces on electrons 1 and 2 are balanced by the electric force

$$\frac{\hbar^2}{2m_e r_2^3} = \frac{\frac{1}{2}e^2}{4\pi\varepsilon_o r_2^2} - \frac{1}{Z}\frac{\hbar^2}{2m_e r_2^3}\sqrt{s(s+1)} \tag{43}$$

where $Z = 1$. Solving for r_2,

$$r_2 = r_1 = a_0\left(1 + \sqrt{s(s+1)}\right); \ s = \frac{1}{2} \tag{44}$$

30 That is, the final radius of electron 2, r_2, is given by Eq. (44); this is also the final radius of electron 1.

54

1.2   Binding Energy

During ionization, electron 2 moves to infinity. By the selection rules for absorption of electromagnetic radiation dictated by conservation of angular momentum, absorption of a photon causes the spin axes of the antiparallel spin-paired electrons to become parallel. The unpairing energy, $E_{unpairing}(magnetic)$, is given by Eq. (7.30) and Eq. (44) multiplied by two because the magnetic energy is proportional to the square of the magnetic field as derived in Eqs. (1.122-1.129). A repulsive magnetic force exists on the electron to be ionized due to the parallel alignment of the spin axes. The energy to move electron 2 to a radius which is infinitesimally greater than that of electron 1 is zero. In this case, the only force acting on electron 2 is the magnetic force. Due to conservation of energy, the potential energy change to move electron 2 to infinity to ionize the hydride ion can be calculated from the magnetic force of Eq. (43). The magnetic work, $E_{magwork}$, is the negative integral of the magnetic force (the second term on the right side of Eq. (43)) from r_2 to infinity,

$$E_{magwork} = \int_{r_2}^{\infty} \frac{\hbar^2}{2m_e r^3} \sqrt{s(s+1)} dr \qquad (45)$$

where r_2 is given by Eq. (44). The result of the integration is

$$E_{magwork} = -\frac{\hbar^2 \sqrt{s(s+1)}}{4m_e a_0^2 \left[1 + \sqrt{s(s+1)}\right]^2} \qquad (46)$$

where $s = \frac{1}{2}$. By moving electron 2 to infinity, electron 1 moves to the radius $r_1 = a_H$, and the corresponding magnetic energy, $E_{electron \, 1 \, final}(magnetic)$, is given by Eq. (7.30). In the present case of an inverse squared central field, the binding energy is one half the negative of the potential energy [Fowles, G. R., Analytical Mechanics, Third Edition, Holt, Rinehart, and Winston, New York, (1977), pp. 154-156.]. Thus, the binding energy can be determined by subtracting the two magnetic energy terms from one half the negative of the magnetic work wherein m_e is the electron reduced mass μ_e given by Eq. (1.167) due to the electrodynamic magnetic force between electron 2 and the nucleus given by one half that of Eq. (1.164). The factor of one half follows from Eq. (43).

55

$$Binding\ Energy = -\frac{1}{2}E_{magwork} - E_{electron\ 1\ final}(magnetic) - E_{unpairing}(magnetic)$$

$$= \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[1 + \sqrt{s(s+1)}\right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3}\left(1 + \frac{2^2}{\left[1 + \sqrt{s(s+1)}\right]^3}\right) \quad (47)$$

The binding energy of the ordinary hydride ion $H^-(n=1)$ is $0.75402\ eV$ according to Eq. (47). The experimental value given by Dean [John A. Dean, Editor, <u>Lange's Handbook of Chemistry</u>, Thirteenth Edition, McGraw-Hill Book Company, New York, (1985), p. 3-10.] is $0.754209\ eV$ which corresponds to a wavelength of $\lambda = 1644\ nm$. Thus, both values approximate to a binding energy of about $0.8\ eV$ for normal hydride ion.

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1.3   Hydrino Hydride Ion

The hydrino atom $H(1/2)$ can form a stable hydride ion, namely, the hydrino hydride ion $H^-(n=1/2)$. The central field of the hydrino atom is twice that of the hydrogen atom, and it follows from Eq. (43) that the radius of the hydrino hydride ion $H^-(n=1/2)$ is one half that of an ordinary hydrogen hydride ion, $H^-(n=1)$, given by Eq. (44).

$$r_2 = r_1 = \frac{a_0}{2}\left(1 + \sqrt{s(s+1)}\right); \; s = \frac{1}{2} \tag{48}$$

The energy follows from Eq. (47) and Eq. (48).

$$Binding \; Energy = -\frac{1}{2}E_{magwork} - E_{electron \; 1 \, final}(magnetic) - E_{unpairing}(magnetic)$$

$$= \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\dfrac{1+\sqrt{s(s+1)}}{2}\right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3}\left(1 + \frac{2^2}{\left[\dfrac{1+\sqrt{s(s+1)}}{2}\right]^3}\right) \tag{49}$$

The binding energy of the hydrino hydride ion $H^-(n=1/2)$ is $3.047 \, eV$ according to Eq. (49), which corresponds to a wavelength of $\lambda = 407 \, nm$. In general, the central field of hydrino atom $H(n=1/p)$; $p =$ integer is p times that of the hydrogen atom. Thus, the force balance equation is

$$\frac{\hbar^2}{2m_e r_2^3} = \frac{\frac{p}{2}e^2}{4\pi\varepsilon_o r_2^2} - \frac{1}{Z}\frac{\hbar^2}{2m_e r_2^3}\sqrt{s(s+1)} \tag{50}$$

where $Z=1$ because the field is zero for $r > r_1$. Solving for r_2,

$$r_2 = r_1 = \frac{a_0}{p}\left(1 + \sqrt{s(s+1)}\right); \; s = \frac{1}{2} \tag{51}$$

From Eq. (51), the radius of the hydrino hydride ion $H^-(n=1/p)$; $p =$ integer is $\frac{1}{p}$ that of atomic hydrogen hydride, $H^-(n=1)$, given by Eq. (44). The energy follows from Eq. (50) and Eq. (51).

$$Binding \; Energy = -\frac{1}{2}E_{magwork} - E_{electron \; 1 \, final}(magnetic) - E_{unpairing}(magnetic)$$

$$= \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\dfrac{1+\sqrt{s(s+1)}}{p}\right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3}\left(1 + \frac{2^2}{\left[\dfrac{1+\sqrt{s(s+1)}}{p}\right]^3}\right) \tag{52}$$

TABLE 1, *supra*, provides the binding energy of the hydrino hydride ion $H^-(n=1/p)$ as a function of p according to Eq. (52).

2. INORGANIC HYDROGEN AND HYDROGEN POLYMER COMPOUNDS

In a further embodiment of the present invention, hydrino hydride ions can be reacted or bonded to any atom of the periodic chart

5   or positively or negatively charged ion thereof such as an alkali or alkaline earth cation, or a proton.   Hydrino hydride ions may also react with or bond to any compound, organic molecule, inorganic molecule, organometalic molecule or compound,   metal, nonmetal, or semiconductor to form an organic molecule, inorganic molecule,

10   compound, metal, nonmetal, organometalic, or semiconductor. Additionally, hydrino hydride ions may react with or bond to ordinary H_2^+, ordinary H_3^+, $H_3^+(1/p)$, $H_4^+(1/p)$, or dihydrino molecular ions

$H_2^* \left[2c' = \dfrac{2a_o}{p} \right]^+$.   Dihydrino molecular ions may bond to hydrino hydride

ions such that the binding energy of the reduced dihydrino molecular

15   ion, the dihydrino molecule $H_2^* \left[2c' = \dfrac{\sqrt{2}a_o}{p} \right]$, is less than the binding energy

of the hydrino hydride ion $H^- \left(\dfrac{1}{p} \right)$ of the compound.

The reactants which may react with hydrino hydride ions include neutral atoms or molecules, negatively or positively charged atomic and molecular ions, and free radicals.   In one embodiment to form hydrino

20   hydride containing compounds, hydrino hydride ions are reacted with a metal.   Thus, in one embodiment of the electrolytic cell hydride reactor, hydrino, hydrino hydride ion, or dihydrino produced during operation at the cathode reacts with the cathode material to form a compound.   In one embodiment of the gas cell hydride reactor, hydrino, hydrino

25   hydride ion, or dihydrino produced during operation reacts with the dissociation material or source of atomic hydrogen to form a compound. A metal-hydrino hydride material can thus be produced.

Exemplary types of compounds of the present invention include those that follow.   Each compound of the invention includes at least one

30   increased binding energy hydrogen species.   The compounds of the present invention may further comprise ordinary hydrogen species, in addition to one or more of the increased binding energy hydrogen species.

58

$H^-(1/p)H_3^+$; MH, MH_2, and M_2H_2 where M is an alkali cation (in the case of M_2H_2, the alkali cations may be different) and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple

5   H; MH_n $n = 1$ to 2 where M is an alkaline earth cation and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; MHX where M is an alkali cation, X is a neutral atom or molecule or a singly negative charged anion, and H is an increased binding energy

10   hydrogen species; MHX where M is an alkaline earth cation, X is a singly negative charged anion, and H is an increased binding energy hydrogen species; MHX where M is an alkaline earth cation, X is a doubly negative charged anion, and H is an increased binding energy hydrogen species; M_2HX where M is an alkali cation (the alkali cations may be different),

15   X is a singly negative charged anion, and H an increased binding energy hydrogen species; MH_n $n = 1$ to 5 where M is an alkaline cation and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; M_2H_n $n = 1$ to 4 where M is an alkaline earth cation and H is at least

20   one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H (the alkaline earth cations may be different); M_2XH_n $n = 1$ to 3 where M is an alkaline earth cation, X is a singly negative charged anion, and H is at least one increased binding energy hydrogen species, and may

25   optionally comprise at least one ordinary hydrogen species in the case of multiple H (the alkaline earth cations may be different); $M_2X_2H_n$ $n = 1$ to 2 where M is an alkaline earth cation, X is a singly negative charged anion, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in

30   the case of multiple H (the alkaline earth cations may be different); M_2X_3H where M is an alkaline earth cation, X is a singly negative charged anion, and H is an increased binding energy hydrogen species (the alkaline earth cations may be different); M_2XH_n $n = 1$ to 2 where M is an alkaline earth cation, X is a doubly negative charged anion, and H is

35   at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of

multiple H (the alkaline earth cations may be different); $M_2XX'H$ where M is an alkaline earth cation, X is a singly negative charged anion, X' is a doubly negative charged anion, and H is an increased binding energy hydrogen species (the alkaline earth cations may be different);

$MM'H_n$ $n = 1$ to 3 where M is an alkaline earth cation, M' is an alkali metal cation, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $MM'XH_n$ $n = 1$ to 2 where M is an alkaline earth cation, M' is an alkali metal cation, X is a singly negative charged anion, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $MM'XH$ where M is an alkaline earth cation, M' is an alkali metal cation, X is a doubly negative charged anion, and H is an increased binding energy hydrogen species; $MM'XX'H$ where M is an alkaline earth cation, M' is an alkali metal cation, X and X' are each a singly negative charged anion, and H is an increased binding energy hydrogen species; H_nS $n = 1$ to 2 where H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $MAlH_n$ $n = 1$ to 6 where M is an alkali or alkaline earth cation and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; MH_n $n = 1$ to 6 where M is a transition, inner transition, or rare earth element cation such as nickel and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $MNiH_n$ $n = 1$ to 6 where M is an alkali cation, alkaline earth cation, silicon, or aluminum and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H, and nickel may be substituted by another transition metal, inner transition, or rare earth cation; TiH_n $n = 1$ to 4 where H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; Al_2H_n $n = 1$ to 4 where H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; AlH_n $n = 1$ to 4 where H is at

60

least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $MXAlX'H_n$ $n = 1$ to 2 where M is an alkali or alkaline earth cation, X and X' are each a singly negative charged anion, or a double negative

5   charged anion, H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H, and another cation such as Si may replace Al; $[KH_mKCO_3]_n$ $m,n =$ integer where H is at least one increased binding energy hydrogen species, and may optionally comprise at least

10   one ordinary hydrogen species in the case of multiple H; $[KHKOH]_n$ $n =$ integer where H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $[KHKNO_3]_n$ $n =$ integer wherein H is at least one increased binding energy hydrogen species, and may optionally

15   comprise at least one ordinary hydrogen species in the case of multiple H; $[KH_mKNO_3]_n^+ nX^-$ $m,n =$ integer where X is a singly negative charged anion, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $[MH_mM'X]_n$ $m,n =$ integer comprising a neutral

20   compound or an anion or cation where M and M' are each an alkali or alkaline earth cation, X is a singly negative charged anion or a doubly negative charged anion, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $[MH_mM'X']_n^+ nX^-$ $m,n =$ integer

25   wherein M and M' are each an alkali or alkaline earth cation, X and X' are each a singly negative charged anion or a doubly negative charged anion, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $[MH_mM'X']_n^{n'+} n'X^-$ $m,m',n,n' =$ integer where M and

30   M' are each an alkali or alkaline earth cation, X and X' are each a singly negative charged anion or a doubly negative charged anion, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $[MH_mM'X']_n^- nM''^+$ $m,n =$ integer where M, M', and M'' are each an

35   alkali or alkaline earth cation, X and X' are each a singly negative

charged anion or a doubly negative charged anion, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $\left[MH_mM'X'\right]_n^{r-}$ $n'M''^+$ $m,m',n,n'=$ integer where M, M', and M'' are each an alkali or alkaline earth cation, X and X' are each a singly negative charged anion or a doubly negative charged anion, and H is at least one increased binding energy hydrogen species in the case of multiple H, and may optionally comprise at least one ordinary hydrogen species; $\left[MH_m\right]_n^{m'+}$ $n'X^-$ $m,m',n,n'=$ integer where M is alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, X is a singly or doubly negative charged anion, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $\left[MH_m\right]_n^{m-}$ $n'M'^+$ $m,m',n,n'=$ integer where M and M' are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $M\left(H_{10}\right)_n$ $n=$ integer where M is other element such as any atom, molecule, or compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M\left(H_{10}\right)_n$ $n=$ integer where M is an increased binding energy hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M^+\left(H_{16}\right)_n^-$ $n=$ integer where M is other element such as an alkali, organic, organometalic, inorganic, or ammonium cation, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M^+\left(H_{16}\right)_n^-$ $n=$ integer where M is an increased binding energy hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M\left(H_{16}\right)_n$ $n=$ integer where M is other element such as any atom, molecule, or compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M\left(H_{16}\right)_n$ $n=$ integer where M is an increased binding energy hydrogen compound, and H is at least

62

one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_{24})_n$ $n =$ integer where M is other element such as any atom, molecule, or compound, and H is at least one increased binding energy hydrogen species, and may

5 optionally comprise at least one ordinary hydrogen species; $M(H_{24})_n$ $n =$ integer where M is an increased binding energy hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_{60})_n$ $n =$ integer where M is other element such as any atom, molecule, or

10 compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_{60})_n$ $n =$ integer where M is an increased binding energy hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary

15 hydrogen species; $M(H_{70})_n$ $n =$ integer where M is other element such as any atom, molecule, or compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_{70})_n$ $n =$ integer where M is an increased binding energy hydrogen compound, and H is at least one

20 increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species;
$M(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ $q,r,s,t,u =$ integer wherein M is other element such as any atom, molecule, or compound, each integer q,r,s,t,u may be zero but not all integers may be zero, the compound contains at least one

25 H, the monomers may be arranged in any order, H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species;
$M(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ $q,r,s,t,u =$ integer wherein M is an increased binding energy hydrogen compound, each integer q,r,s,t,u may be zero

30 but not all integers may be zero, the compound contains at least one H, the monomers may be arranged in any order, H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; MX where M is positive, neutral, or negative and is selected from the list of H_{16}, $H_{16}H$, $H_{16}H_2$, $H_{24}H_{23}$, OH_{22},

35 OH_{23}, OH_{24}, MgH_2 H_{16}, NaH_3 H_{16}, $H_{24}H_2O$, CNH_{16}, CH_{30}, SiH_4H_{16}, $(H_{16})_3H_{15}$,

63

$SiH_4(H_{16})_2$, $(H_{16})_4$, H_{70}, $Si_2H_6H_{16}$, $(SiH_4)_2H_{16}$, $SiH_4(H_{16})_3$, CH_{70}, NH_{69}, NH_{70}, NHH_{70}, OH_{70}, H_2OH_{70}, FH_{70}, H_3OH_{70}, SiH_2H_{60}, $Si(H_{16})_3H_{15}$, $Si(H_{16})_4$, $Si_2H_6(H_{16})_2$, $Si_2H_7(H_{16})_2$, $SiH_3(H_{16})_4$, $(SiH_4)_2(H_{16})_2$, $O_2(H_{16})_4$, $SiH_4(H_{16})_4$, NOH_{70}, O_2H_{69}, $HONH_{70}$, O_2H_{70}, H_2ONH_{70}, $H_3O_2H_{70}$, $Si_2H_6(H_{24})_2$, $Si_2H_6(H_{16})_3$, $(SiH_4)_3H_{16}$, $(SiH_4)_2(H_{16})_3$, $(OH_{23})H_{16}H_{70}$,

5    $(OH_{24})H_{16}H_{70}$, $Si_3H_{10}(H_{16})_2$, Si_2H_{70}, $Si_3H_{11}(H_{16})_2$, $Si_2H_7(H_{16})_4$, $(SiH_4)_3(H_{16})_2$, $(SiH_4)_2(H_{16})_4$, $NaOSiH_2(H_{16})_4$, $NaKH\,H_{70}$, $Si_2H_7(H_{70})$, $Si_3H_9(H_{16})_3$, $Si_3H_{10}(H_{16})_3$, $Si_2H_6(H_{16})_5$, $(SiH_4)_4H_{16}$, $(SiH_4)_3(H_{16})_3$, $Na_2OSiH_2(H_{16})_4$, $Si_3H_8(H_{16})_4$, $Na_2KH\,H_{70}$, $Si_3H_9(H_{16})_4$, $Na_2HKH\,H_{70}$, $SO(H_{16})_6(H_{15})$, $SH_2(OH_{23})H_{16}H_{70}$, $SO(H_{16})_7$, $Mg_2H_2H_{23}H_{16}H_{70}$, $(SiH_4)_4(H_{16})_2$, $(SiH_4)_3(H_{16})_4$, $KH_3O(H_{16})_2H_{70}$, $KH_5O(H_{16})_2H_{70}$,

10    $K(OH_{23})H_{16}H_{70}$, $K_2OH\,H_{70}$, $NaKHO_2H_{70}$, $NaOHNaO_2\,H_{70}$, $HNO_3\,O_2\,H_{70}$, $Rb(H_{16})_5$, $Si_3H_{11}H_{70}$, $KNO_2(H_{16})_5$, $(SiH_4)_4(H_{16})_3$, $KKH(H_{16})_7$, $(SiH_4)_4(H_{16})_4$, $(KH_2)_2(H_{16})_3H_{70}$, $(NiH_2)_2HCl(H_{16})_2H_{70}$, Si_5OH_{102}, $(SiH_3)_7(H_{16})_5$, $Na_3O_3(SiH_3)_{10}SiH(H_{16})_5$, X is other element, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen

15   species; MX where M is positive, neutral, or negative and is selected from the list of H_{16}, $H_{16}H$, $H_{16}H_2$, $H_{24}H_{23}$, OH_{22}, OH_{23}, OH_{24}, $MgH_2\,H_{16}$, $NaH_3\,H_{16}$, $H_{24}H_2O$, CNH_{16}, CH_{30}, SiH_4H_{16}, $(H_{16})_3H_{15}$, $SiH_4(H_{16})_2$, $(H_{16})_4$, H_{70}, $Si_2H_6H_{16}$, $(SiH_4)_2H_{16}$, $SiH_4(H_{16})_3$, CH_{70}, NH_{69}, NH_{70}, NHH_{70}, OH_{70}, H_2OH_{70}, FH_{70}, H_3OH_{70}, SiH_2H_{60}, $Si(H_{16})_3H_{15}$, $Si(H_{16})_4$, $Si_2H_6(H_{16})_2$, $Si_2H_7(H_{16})_2$, $SiH_3(H_{16})_4$, $(SiH_4)_2(H_{16})_2$,

20    $O_2(H_{16})_4$, $SiH_4(H_{16})_4$, NOH_{70}, O_2H_{69}, $HONH_{70}$, O_2H_{70}, H_2ONH_{70}, $H_3O_2H_{70}$, $Si_2H_6(H_{24})_2$, $Si_2H_6(H_{16})_3$, $(SiH_4)_3H_{16}$, $(SiH_4)_2(H_{16})_3$, $(OH_{23})H_{16}H_{70}$, $(OH_{24})H_{16}H_{70}$, $Si_3H_{10}(H_{16})_2$, Si_2H_{70}, $Si_3H_{11}(H_{16})_2$, $Si_2H_7(H_{16})_4$, $(SiH_4)_3(H_{16})_2$, $(SiH_4)_2(H_{16})_4$, $NaOSiH_2(H_{16})_4$, $NaKH\,H_{70}$, $Si_2H_7(H_{70})$, $Si_3H_9(H_{16})_3$, $Si_3H_{10}(H_{16})_3$, $Si_2H_6(H_{16})_5$, $(SiH_4)_4H_{16}$, $(SiH_4)_3(H_{16})_3$, $Na_2OSiH_2(H_{16})_4$, $Si_3H_8(H_{16})_4$, $Na_2KH\,H_{70}$, $Si_3H_9(H_{16})_4$, $Na_2HKH\,H_{70}$, $SO(H_{16})_6(H_{15})$,

25    $SH_2(OH_{23})H_{16}H_{70}$, $SO(H_{16})_7$, $Mg_2H_2H_{23}H_{16}H_{70}$, $(SiH_4)_4(H_{16})_2$, $(SiH_4)_3(H_{16})_4$, $KH_3O(H_{16})_2H_{70}$, $KH_5O(H_{16})_2H_{70}$, $K(OH_{23})H_{16}H_{70}$, $K_2OH\,H_{70}$, $NaKHO_2H_{70}$, $NaOHNaO_2\,H_{70}$, $HNO_3\,O_2\,H_{70}$, $Rb(H_{16})_5$, $Si_3H_{11}H_{70}$, $KNO_2(H_{16})_5$, $(SiH_4)_4(H_{16})_3$, $KKH(H_{16})_7$, $(SiH_4)_4(H_{16})_4$, $(KH_2)_2(H_{16})_3H_{70}$, $(NiH_2)_2HCl(H_{16})_2H_{70}$, Si_5OH_{102}, $(SiH_3)_7(H_{16})_5$, $Na_3O_3(SiH_3)_{10}SiH(H_{16})_5$, X is an increased binding energy

30   hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_x)_n$ x = integer from 8 to 10; n = integer where M is other element such as any atom, molecule, or compound, and H is at least one increased binding energy hydrogen species, and may optionally
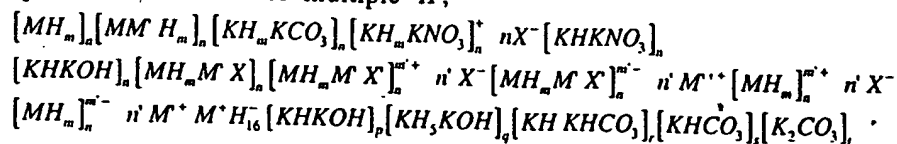
64

comprise at least one ordinary hydrogen species; $M(H_x)_n$

x = integer from 8 to 10; n = integer where M is an increased binding energy hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M^+(H_x)_n^-$ x = integer from 14 to 18; n = integer where M is other element such as an alkali, organic, organometalic, inorganic, or ammonium cation, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M^+(H_x)_n^-$ x = integer from 14 to 18; n = integer where M is an increased binding energy hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_x)_n$

x = integer from 14 to 18; n = integer where M is other element such as any atom, molecule, or compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_x)_n$ x = integer from 14 to 18; n = integer where M is an increased binding energy hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_x)_n$

x = integer from 22 to 26; n = integer where M is other element such as any atom, molecule, or compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_x)_n$ x = integer from 22 to 26; n = integer where M is an increased binding energy hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_x)_n$

x = integer from 58 to 62; n = integer where M is other element such as any atom, molecule, or compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_x)_n$ x = integer from 58 to 62; n = integer where M is an increased binding energy hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_x)_n$

x = integer from 68 to 72; n = integer where M is other element such as any atom, molecule, or compound, and H is at least one increased binding

energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_x)_n$ $x =$ integer from 68 to 72; $n =$ integer where M is an increased binding energy hydrogen compound, and H is at least one increased binding energy hydrogen species, and may optionally

5 comprise at least one ordinary hydrogen species;

$M(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ $q,r,s,t,u =$ integer; $x =$ integer from 8 to 12;

$x' =$ integer from 14 to 18; $y =$ integer from 22 to 26; $y' =$ integer from 58 to 62;

$z =$ integer from 68 to 72 wherein M is other element such as any atom, molecule, or compound, each integer q,r,s,t,u may be zero but not all

10 integers may be zero, the compound contains at least one H, the monomers may be arranged in any order, H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ $q,r,s,t,u =$ integer;

$x =$ integer from 8 to 12; $x' =$ integer from 14 to 18; $y =$ integer from 22 to 26;

15 $y' =$ integer from 58 to 62; $z =$ integer from 68 to 72 wherein M is an increased binding energy hydrogen compound, wherein each integer q,r,s,t,u may be zero but not all integers may be zero, the compound contains at least one H, the monomers may be arranged in any order, H is at least one increased binding energy hydrogen species, and may optionally

20 comprise at least one ordinary hydrogen species;

$[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$ $p,q,r,s,t =$ integer

wherein each integer p,q,r,s,t may be zero but not all integers may be zero, the compound contains at least one H, the monomers may be arranged in any order, H is at least one increased binding energy

25 hydrogen species, and may optionally comprise at least one ordinary hydrogen species;

$[MH_m]_n[MM'\,H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+$ nX^- $[KHKNO_3]_n[KHKOH]_n[MH_mM'\,X]_n$
$[MH_mM'\,X]_n^{m'+}$ $n'\,X^-[MH_mM'\,X]_n^{m'-}$ $n'\,M'^{+}[MH_m]_n^{m'+}$ $n'\,X^-[MH_m]_n^{m'-}$ $n'\,M'^{+}\,M^+H_{16}^-$
$[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$ $n,n',m,m',p,q,r,s,t =$ integers

30 wherein M, M', and M'' are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, X and X' are each a singly negative charged anion or a doubly negative charged anion, each integer n,n',m,m',p,q,r,s,t may be zero but not all integers may be zero, the compound contains at least one H, the monomers may be arranged

35 in any order, H is at least one increased binding energy hydrogen

66

species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H;

$$[MH_m]_n[MM'H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+ \, nX^-[KHKNO_3]_n$$
$$[KHKOH]_n[MH_mM'X]_n[MH_mM'X]_n^{m'+} \, n'X^-[MH_mM'X]_n^{m'-} \, n'M'^+[MH_m]_n^{m'+} \, n'X^-$$
$$[MH_m]_n^{m'-} \, n'M'^+ M'H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$$
$$M'''(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_r(H_{70})_u \quad n,n',m,m',p,q,r,s,t,q',r',s',t',u = \text{integers} \quad \text{wherein}$$

M, M', and M' are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, M''' is other element, X and X' are a singly or doubly negative charged anion, each integer $n,n',m,m',p,q,r,s,t,q',r',s',t',u$ may be zero but not all integers may be zero, the compound contains at least one H, the monomers may be arranged in any order, H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H;

$$[MH_m]_n[MM'H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+ \, nX^-[KHKNO_3]_n$$
$$[KHKOH]_n[MH_mM'X]_n[MH_mM'X]_n^{m'+} \, n'X^-[MH_mM'X]_n^{m'-} \, n'M'^+[MH_m]_n^{m'+} \, n'X^-$$
$$[MH_m]_n^{m'-} \, n'M'^+ M'H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$$
$$M'''(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_r(H_{70})_u \quad n,n',m,m',p,q,r,s,t,q',r',s',t',u = \text{integers} \quad \text{wherein}$$

M, M', and M' are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, M''' is an increased binding energy hydrogen compound, X and X' are a singly or doubly negative charged anion, each integer $n,n',m,m',p,q,r,s,t,q',r',s',t',u$ may be zero but not all integers may be zero, the compound contains at least one H, the monomers may be arranged in any order, H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H;

$$[MH_m]_n[MM'H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+ \, nX^-[KHKNO_3]_n$$
$$[KHKOH]_n[MH_mM'X]_n[MH_mM'X]_n^{m'+} \, n'X^-[MH_mM'X]_n^{m'-} \, n'M'^+[MH_m]_n^{m'+} \, n'X^-$$
$$[MH_m]_n^{m'-} \, n'M'^+ M'H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$$
$$M'''(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u \quad n,n',m,m',p,q,r,s,t,q',r',s',t',u = \text{integers};$$

x = integer from 8 to 12; x' = integer from 14 to 18; y = integer from 22 to 26; y' = integer from 58 to 62; z = integer from 68 to 72 wherein M, M', and M' are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, M''' is other element, X and X' are a singly or doubly

negative charged anion, each integer $n,n',m,m',p,q,r,s,t,q',r',s',t',u$ may be zero but not all integers may be zero, the compound contains at least one H, the monomers may be arranged in any order, H is at least one increased binding energy hydrogen species, and may optionally

5 comprise at least one ordinary hydrogen species in the case of multiple H; $[MH_m]_n[MM'\,H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+\,nX^-[KHKNO_3]_n$
$[KHKOH]_n[MH_mM'\,X]_n[MH_mM'\,X]_n^{m^+}\,n'\,X^-[MH_mM'\,X]_n^{m'-}\,n'\,M'^+[MH_m]_n^{m'+}\,n'\,X^-$
$[MH_m]_n^{m'-}\,n'\,M'^+\,M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$
$M'''(H_x)_{q'}(H_{x'})_{r'}(H_y)_{s'}(H_{y'})_{t'}(H_z)_u\quad n,n',m,m',p,q,r,s,t,q',r',s',t',u = $ integers;

1 0 $x = $ integer from 8 to 12; $x' = $ integer from 14 to 18; $y = $ integer from 22 to 26;
$y' = $ integer from 58 to 62; $z = $ integer from 68 to 72 wherein M, M', and M'' are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, M''' is an increased binding energy hydrogen compound, X and X' are a singly or doubly negative charged anion, each

1 5 integer $n,n',m,m',p,q,r,s,t,q',r',s',t',u$ may be zero but not all integers may be zero, the compound contains at least one H, the monomers may be arranged in any order, H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H;

2 0 $[MH_m]_n[MM'\,H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+\,nX^-[KHKNO_3]_n$
$[KHKOH]_n[MH_mM'\,X]_n[MH_mM'\,X]_n^{m'+}\,n'\,X^-[MH_mM'\,X]_n^{m'-}\,n'\,M'^+[MH_m]_n^{m'+}\,n'\,X^-$
$[MH_m]_n^{m'-}\,n'\,M'^+\,M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$
$M'''(H_x)_{q'}(H_{x'})_{r'}(H_y)_{s'}(H_{y'})_{t'}(H_z)_u\quad n,n',m,m',p,q,r,s,t,q',r',s',t',u = $ integers;
$x = $ integer from 8 to 12; $x' = $ integer from 14 to 18; $y = $ integer from 22 to 26;

2 5 $y' = $ integer from 58 to 62; $z = $ integer from 68 to 72 wherein M, M', and M'' are each a metal such as silicon, aluminum, Group III A elements, Group IVA elements, a transition metal, inner transition metal, tin, boron, or a rare earth, lanthanide, an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, M''' is other element, X and X' are a

3 0 singly or doubly negative charged anion, each integer $n,n',m,m',p,q,r,s,t,q',r',s',t',u$ may be zero but not all integers may be zero, the compound contains at least one H, the monomers may be arranged in any order, H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen

68

species in the case of multiple H;

$$[MH_m]_a[MM'H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^* \; nX^-[KHKNO_3]_n$$

$$[KHKOH]_n[MH_mM'X]_n[MH_mM'X]_n^{m'+} \; n'X^-[MH_mM'X]_n^{m'-} \; n'M''^+[MH_m]_n^{m'+} \; n'X^-$$

$$[MH_m]_n^{m'-} \; n'M'^+ M'H_{16}^-[KHKOH]_p[KH_5KOH]_q[KHKHCO_3]_r[KHCO_3]_r[K_2CO_3]_t \; \cdot$$

$$M''(H_x)_q(H_{x'})_r(H_y)_{s'}(H_{y'})_t(H_z)_u \quad n,n',m,m',p,q,r,s,t,q',r',s',t',u = \text{integers};$$

x = integer from 8 to 12; x' = integer from 14 to 18; y = integer from 22 to 26;
y' = integer from 58 to 62; z = integer from 68 to 72 wherein M, M', and M'' are
each a metal such as silicon, aluminum, Group III A elements, Group IVA
elements, a transition metal, inner transition metal, tin, boron, or a rare
earth, lanthanide, an alkali or alkaline earth, organic, organometalic,
inorganic, or ammonium cation, M''' is an increased binding energy
hydrogen compound, X and X' are a singly or doubly negative charged
anion, each integer $n,n',m,m',p,q,r,s,t,q',r',s',t',u$ may be zero but not all
integers may be zero, the compound contains at least one H, the
monomers may be arranged in any order, H is at least one increased
binding energy hydrogen species, and may optionally comprise at least
one ordinary hydrogen species in the case of multiple H.

Exemplary silanes, siloxanes, and silicates that may form polymers
each have unique observed characteristics different from those of the
corresponding ordinary compound wherein the hydrogen content is only
ordinary hydrogen H. The observed characteristics which are dependent
on the increased binding energy of the hydrogen species include
stoichiometry, stability at elevated temperature, and stability in air.
Exemplary compounds are:

$MSiH_n$ $n = 1$ to 6 where M is an alkali or alkaline earth cation and H
is at least one increased binding energy hydrogen species, and may
optionally comprise at least one ordinary hydrogen species in the case of
multiple H; $MXSiH_n$ $n = 1$ to 5 where M is an alkali or alkaline earth cation,
Si may be replaced by Al, Ni, transition, inner transition, or rare earth
element, X is a singly negative charged anion or a double negative
charged anion, and H is at least one increased binding energy hydrogen
species, and may optionally comprise at least one ordinary hydrogen
species in the case of multiple H; M_2SiH_n $n = 1$ to 8 wherein M is an alkali
or alkaline earth cation (the cations may be different) and H is at least

69

one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; Si_2H_n $n = 1$ *to* 8 wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; SiH_n $n = 1$ *to* 8 wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; Si_nH_{4n} $n = $ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; Si_nH_{3n} $n = $ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $Si_nH_{4n}O$ $m, n = $ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $Si_xH_{4x-2y}O_y$ $x, y = $ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $Si_xH_{4x}O_y$ $x, y = $ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $Si_nH_{4n} \cdot H_2O$ $n = $ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; Si_nH_{2n+2} $n = $ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $Si_xH_{2x+2}O_y$ $x, y = $ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $MSi_{4n}H_{10n}O_n$ $n = $ integer wherein M is an alkali or alkaline earth cation and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $MSi_{4n}H_{10n}O_{n+1}$ $n = $ integer wherein M is an alkali or alkaline earth cation and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species; $M_qSi_nH_mO_p$ $q, n, m, p = $ integer wherein M is an alkali or alkaline earth cation and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $M_qSi_nH_m$ $q, n, m = $ integer wherein M is an alkali or alkaline earth cation and H is at least one increased binding energy

hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $Si_nH_mO_p$ $n,m,p =$ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; Si_nH_m $n,m =$ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; SiO_2H_n $n = 1$ to 6 wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $MSiO_2H_n$ $n = 1$ to 6 wherein M is an alkali or alkaline earth cation and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; MSi_2H_n $n = 1$ to 14 wherein M is an alkali or alkaline earth cation and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; M_2SiH_n $n = 1$ to 8 wherein M is an alkali or alkaline earth cation and H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; and polyalkylsiloxane wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H; $Si_xH_y(H_{16})_z$ $x =$ integer; $y =$ integer from $2x + 2$ to $4x$; $z =$ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species.

Examples of the singly negative charged anions disclosed herein include but are not limited to halogen ions, hydroxide ion, hydrogen carbonate ion, and nitrate ion. Examples of the doubly negative charged anions disclosed herein include but are not limited to carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion.

Preferred metals M of increased binding energy hydrogen compounds having a formulae such as MH_n $n = 1$ to 8 wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least one ordinary hydrogen species in the case of multiple H include the Group VIB (Cr, Mo, W) and Group IB (Cu, Ag, Au) elements. The compounds are useful for purification of the metals. The

purification is achieved via formation of the increased binding energy hydrogen compounds that have a high vapor pressure. Each compound is isolated by cryopumping.

In an embodiment of a superconductor of reduced dimensionality
5 of the present invention, at least one increased binding energy hydrogen species, and optionally at least one ordinary hydrogen species, is reacted with or bonded to a source of electrons. The source of electrons may be any positively charged other element such as any atom of the periodic chart such as an alkali, alkaline earth, transition metal, inner transition
10 metal, rare earth, lanthanide, or actinide cation to form a structure described by a lattice described in '99 Mills GUT (pages 270-289 which are incorporated by reference). Exemplary superconductors can be formulated from an increased binding energy hydrogen polymer, an inorganic increased binding energy hydrogen polymer, a metal hydrino
15 hydride polymer, an alkali-transition metal hydrino hydride polymer, and a compound comprising a neutral, positive, or negative polymer of increased binding energy hydrogen species.

A xerographic toner may comprise an increased binding energy hydrogen compound. The toner may be a mixture of an increased
20 binding energy hydrogen compound and at least one additional compound or material such as a carbon compound. Increased binding energy hydrogen compounds that have one or more of the following properties, 1.) readily form stable charge ions, 2.) form highly charged ions, 3.) attach to carrier particles, and 4.) bind to a substrate such as
25 paper are preferred toner compounds. Exemplary ions and compounds are polyhydrogen ions such as $NaH_{70}H_{23}^{3+}$, OH_{23}^{+}, H_{16}^{-}, and silanes which may form positive or negative ions such as $Si_xH_y(H_{16})_z$ $x =$ integer;

$y =$ integer from $2x+2$ to $4x$; $z =$ integer wherein H is at least one increased binding energy hydrogen species, and may optionally comprise at least
30 one ordinary hydrogen species.

Magnetic increased binding energy hydrogen compounds such as metal hydrino hydrides, alkali-transition metal hydrino hydrides, and polyhydrogen compounds may be useful as magnets, magnetic materials, or may comprise a magnetic computer memory storage material to coat
35 a floppy disk for example. The compound may have the formula MH_n wherein n is an integer from 1 to 6, M is a transition element, an inner

72

transition element, a rare earth element, or Ni, and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species. The compound may have the formula $MNiH_n$ wherein n is an integer from 1 to 6, M is an alkali cation, alkaline earth cation,

5 silicon, or aluminum, and the hydrogen content H_n of the compound comprises at least one increased binding energy hydrogen species. The compound may have the formula $MM'H_n$ wherein n is an integer from 1 to 6, M is an alkali cation, alkaline earth cation, silicon, or aluminum, M' is a transition element, inner transition element, or a rare earth element

10 cation, and the hydrogen content H_n of the compound The compound may have the formula $M(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ wherein q, r, s, t, and u are each an integer including zero but not all zero, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ of the compound comprises at least one

15 increased binding energy hydrogen species. The compound may have the formula $M(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ wherein q, r, s, t, and u are each an integer including zero but not all zero, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ of the compound comprises at least one

20 increased binding energy hydrogen species.

Increased binding energy hydrogen compounds comprising a desired element may be synthesized by placing the element in the gas cell hydrino hydride reactor. The element may be a foil. For example, gold hydrino hydride may be synthesized by placing a gold foil or gold

25 containing substrate into a gas cell such as a gas cell comprising a titanium dissociator and a KI or KBr catalyst. The gold hydrino hydride film that forms may be analyzed by TOFSIMS. Magnetic compounds such as nickel, cobalt, or samarium hydrino hydride may be synthesized by placing foils of these elements in a gas cell hydrino hydride reactor.

30 These metal hydrino hydrides may be useful as magnets, magnetic materials, as computer memory storage materials, or wherever magnetic properties are desired. Actinide, lanthanide, silanes, and semiconductor hydrino hydride compounds may be synthesized by placing the reactant actinides, lanthanides, silicon, and semiconductors such as gallium in the

gas cell hydrino hydride reactor. The products may be collected from the cell, purified, and analyzed by TOFSIMS.

3. METHOD OF ISOTOPE SEPARATION

5   The selectivity of hydrino atoms and hydride ions to form bonds with specific isotopes based on a differential in bond energy provides a means to purify desired isotopes of elements such as $^{235}_{92}U$ and $^{239}_{94}Pu$. The term isotope as used herein refers to any isotope given in the CRC which is herein incorporated by reference [R. C. Weast, Editor, CRC Handbook of

10   Chemistry and Physics, 58th Edition, CRC Press, (1977), pp., B-270-B-354]. Differential bond energy can arise from a difference in the nuclear moments of the isotopes, and with a sufficient difference they can be separated.

        A method of isotope separation comprises the step of reacting an

15   element or compound having an isotopic mixture containing the desired element with an increased binding energy hydrogen species in atomic percent shortage based on the stoichiometric amount to fully react with the desired isotope. The increased binding energy hydrogen species is selected such that the bond energy of the reaction product is dependent

20   on the isotope of the desired element. Thus, an increased binding energy species can be selected such that the predominant reaction product contains at least one increased binding energy hydrogen species bound to the desired isotope. The compound comprising at least one increased binding energy hydrogen species and the desired isotope can

25   be separated from the reaction mixture. The increased binding energy hydrogen species may be separated from the desired isotope to obtain the desired isotope. The recovered isotope may be reacted with the increased binding energy hydrogen species and these steps may be repeated to obtain a desired level of enrichment. The use of the term

30   "isotope" in this context includes an individual element as well as compounds containing the desired elemental isotope.

        A method of isotope separation comprises the step of reacting an element or compound having an isotopic mixture containing the desired element with an increased binding energy hydrogen species to bond

35   with the undesired isotope. Since the bond energy of the reaction product is dependent on the isotope of the undesired element, an

74

increased binding energy species can be selected such that the predominant reaction product contains at least one increased binding energy hydrogen species bound to the undesired isotope, and the desired isotope remains substantially unbound. The compound

5   comprising at least one increased binding energy hydrogen species and the undesired isotope can be separated from the reaction mixture to obtain the desired isotope. If less than a stoichiometric amount of increased binding energy hydrogen is used, these steps may be repeated until the desired level of enrichment is obtained. The use of

10   the term "isotope" in this context includes an individual element as well as compounds containing the desired elemental isotope.

A method of isotope separation comprises the step of reacting an element or compound having an isotopic mixture containing the desired element with an increased binding energy hydrogen species in atomic

15   percent shortage based on the stoichiometric amount to fully react with the undesired isotope. Since the bond energy of the reaction product is dependent on the isotope of the undesired element, an increased binding energy species can be selected such that the predominant reaction product contains at least one increased binding energy

20   hydrogen species bound to the undesired isotope, and the desired isotope remains substantially unbound. The compound comprising at least one increased binding energy hydrogen species and the undesired isotope can be separated from the reaction mixture to obtain the desired isotope. The recovered enriched desired isotope may be reacted

25   with the increased binding energy hydrogen species and these steps may be repeated to obtain a desired level of enrichment. The use of the term "isotope" in this context includes an individual element as well as compounds containing the desired elemental isotope.

Sources of reactant increased binding energy hydrogen species

30   include the electrolytic cell, gas cell, gas discharge cell, and plasma torch cell hydrino hydride reactors of the present invention and increased binding energy hydrogen compounds. The increased binding energy hydrogen species may be an increased binding energy hydride ion. The compound comprising at least one increased binding energy hydrogen

35   species and the desired isotopically enriched element can be separated by any conventional method. In a further embodiment, the compound

can be reacted to form a different compound. The increased binding
energy hydrogen species can be separated from the desired isotope or
compound containing the isotope, for example, by a decomposition
reaction such as a plasma discharge or plasma torch reaction or
5   displacement reaction of the increased binding energy hydrogen
species.

For example, a hydrino hydride electrolytic cell can be operated
with a K_2CO_3 catalyst. Increased binding energy hydrogen compounds
such as $KHK^{17}OH$ and $KHK^{18}OH$ form preferentially. The electrolyte
10   comprising a mixture of catalyst, $KHK^{17}OH$, and $KHK^{18}OH$ may be
concentrated and $KHK^{17}OH$ and $KHK^{18}OH$ allowed to precipitate to yield
compounds which are isotopically enriched in ^{17}O or ^{18}O, compared to
^{16}O.

Another method to obtain ^{17}O and ^{18}O comprises reacting a
15   hydrino hydride compound such as KH_2I with a source of oxygen such
as water to form $KHKOH$ which is enriched in ^{17}O and ^{18}O. The desired
oxygen isotope may be collected as oxygen gas by decomposing the
$KHKOH$ by methods such as thermal decomposition.

For example, a hydrino hydride electrolytic cell can be operated
20   with a K_2CO_3 catalyst. Increased binding energy hydrogen compounds
such as $KHK^{17}OH$ and $KHK^{18}OH$ form preferentially. The electrolyte
comprising a mixture of catalyst, $KHK^{17}OH$, and $KHK^{18}OH$ may be
concentrated and $KHK^{17}OH$ and $KHK^{18}OH$ allowed to precipitate to yield
compounds in which are isotopically enriched in ^{16}O.

25   Differential bond energy can arise from a difference in the nuclear
moments of the isotopes and/or a difference in masses of the isotopes, and
with a sufficient difference they can be separated. This mechanism can be
enhanced as the temperature is reduced. Thus, separation can be
enhanced by forming the increased binding energy compounds and
30   performing the separation at lower temperatures.

The mass of tritium is the largest of any hydrogen isotope, and the
nuclear magnetic moment is the largest. Thus, the electrolyte of a
K_2CO_3/ D_2O cell may become enriched in tritium compounds during
electrolysis due to selective bonding of the tritium isotope to form hydrino
35   hydride compounds. These compounds may be isolated and decomposed
to release tritium.

3. EXPERIMENTAL

3.1 Synthesis and Isolation of Inorganic Hydrogen Polymer Compounds

5   3.1.1 Electrolytic Cell Hydrino Hydride Reactor

            An electrolytic cell hydride reactor of the present invention is
     shown in FIGURE 1. An electric current is passed through an electrolytic
     solution 102 contained in vessel 101 by the application of a voltage. The
10   voltage is applied to an anode 104 and cathode 106 by a power
     controller 108 powered by a power supply 110. The electrolytic solution
     102 contains a catalyst for producing hydrino atoms.
            According to one embodiment of the electrolytic cell hydride
     reactor, cathode 106 is formed of nickel cathode 106 and anode 104 is
15   formed of platinized titanium or nickel. The electrolytic solution 102
     comprising an about $0.5M$ aqueous K_2CO_3 electrolytic solution (K^+ / K^+
     catalyst) is electrolyzed. The cell is operated within a voltage range of
     1.4 to 3 volts. In one embodiment of the invention, the electrolytic
     solution 102 is molten.
20   Hydrino atoms form at the cathode 106 via contact of the catalyst
     of electrolyte 102 with the hydrogen atoms generated at the cathode
     106. The electrolytic cell hydride reactor apparatus further comprises a
     source of electrons in contact with the hydrinos generated in the cell, to
     form hydrino hydride ions. The hydrinos are reduced (i.e. gain the
25   electron) in the electrolytic cell to hydrino hydride ions. Reduction
     occurs by contacting the hydrinos with any of the following: 1.) the
     cathode 106, 2.) a reductant which comprises the cell vessel 101, or 3.)
     any of the reactor's components such as features designated as anode
     104 or electrolyte 102, or 4.) a reductant 160 extraneous to the
30   operation of the cell (i.e. a consumable reductant added to the cell from
     an outside source). Any of these reductants may comprise an electron
     source for reducing hydrinos to hydrino hydride ions.
            A compound may form in the electrolytic cell between the hydrino
     hydride ions and cations. The cations may comprise, for example, any of
35   the cations described herein, in particular an oxidized species of the

material of the cathode or anode, a cation of an added reductant, or a cation of the electrolyte (such as a cation comprising the catalyst).

Inorganic hydrogen polymer compounds were prepared during the electrolysis of an aqueous solution of K_2CO_3 corresponding to the catalyst

5   K^+ / K^+. The cell comprised a 10 gallon (33 in. x 15 in.) Nalgene tank (Model # 54100-0010). Two 4 inch long by 1/2 inch diameter terminal bolts were secured in the lid, and a cord for a calibration heater was inserted through the lid. The cell assembly is shown in FIGURE 1.

The cathode comprised 1.) a 5 gallon polyethylene bucket which

10 served as a perforated (mesh) support structure where 0.5 inch holes were drilled over all surfaces at 0.75 inch spacings of the hole centers and 2.) 5000 meters of 0.5 mm diameter clean, cold drawn nickel wire (NI 200 0.0197", HTN36NOAG1, A1 Wire Tech, Inc.). The wire was wound uniformly around the outside of the mesh support as 150

15 sections of 33 meter length. The ends of each of the 150 sections were spun to form three cables of 50 sections per cable. The cables were pressed in a terminal connector which was bolted to the cathode terminal post. The connection was covered with epoxy to prevent corrosion.

20 The anode comprised an array of 15 platinized titanium anodes (10 - Engelhard Pt/Ti mesh 1.6" x 8" with one 3/4" by 7" stem attached to the 1.6" side plated with 100 U series 3000; and 5 - Engelhard 1" diameter x 8" length titanium tubes with one 3/4" x 7" stem affixed to the interior of one end and plated with 100 U Pt series 3000). A 3/4"

25 wide tab was made at the end of the stem of each anode by bending it at a right angle to the anode. A 1/4" hole was drilled in the center of each tab. The tabs were bolted to a 12.25" diameter polyethylene disk (Rubbermaid Model #JN2-2669) equidistantly around the circumference. Thus, an array was fabricated having the 15 anodes

30 suspended from the disk. The anodes were bolted with 1/4" polyethylene bolts. Sandwiched between each anode tab and the disk was a flattened nickel cylinder also bolted to the tab and the disk. The cylinder was made from a 7.5 cm by 9 cm long x 0.125 mm thick nickel foil. The cylinder traversed the disk and the other end of each was

35 pressed about a 10 AWG/600 V copper wire. The connection was sealed with shrink tubing and epoxy. The wires were pressed into two

78

terminal connectors and bolted to the anode terminal. The connection was covered with epoxy to prevent corrosion.

Before assembly, the anode array was cleaned in 3 M *HCL* for 5 minutes and rinsed with distilled water. The cathode was cleaned by

5 placing it in a tank of 0.57 M $K_2CO_3/3\%$ H_2O_2 for 6 hours and then rinsing it with distilled water. The anode was placed in the support between the central and outer cathodes, and the electrode assembly was placed in the tank containing electrolyte. The power supply was connected to the terminals with battery cables.

10 The electrolyte solution comprised 28 liters of 0.57 M K_2CO_3 (Alfa K_2CO_3 99±%).

The calibration heater comprised a 57.6 ohm 1000 watt Incolloy 800 jacketed Nichrome heater which was suspended from the polyethylene disk of the anode array. It was powered by an Invar

15 constant power (± 0.1% supply (Model #TP 36-18). The voltage (± 0.1%) and current (± 0.1%) were recorded with a Fluke 8600A digital multimeter.

Electrolysis was performed at 20 amps constant current with a constant current (± 0.02%) power supply (Kepco Model # ATE 6 -

20 100M).

The voltage (± 0.1%) was recorded with a Fluke 8600A digital multimeter. The current (± 0.5%) was read from an Ohio Semitronics CTA 101 current transducer.

The temperature (± 0.1 °C) was recorded with a microprocessor

25 thermometer Omega HH21 using a type K thermocouple which was inserted through a 1/4" hole in the tank lid and anode array disk. To eliminate the possibility that temperature gradients were present, the temperature was measured throughout the tank. No position variation was found to within the detection of the thermocouple

30 (± 0.1 °C).

The temperature rise above ambient ($\Delta T = T(electrolysis\ only) - T(blank)$) and electrolysis power were recorded daily. The heating coefficient was determined "on the fly" by turning an internal resistance heater off and on, and inferring the cell constant from

35 the difference between the losses with and without the heater. 20 watts of heater power were added to the electrolytic cell every 72 hours

79

where 24 hours was allowed for steady state to be achieved. The temperature rise above ambient ($\Delta T_2 = T(electrolysis + heater) - T(blank)$) was recorded as well as the electrolysis power and heater power.

In all temperature measurements, the "blank" comprised 28 liters of water in a 10 gallon (33" x 15") Nalgene tank with lid (Model #54100-0010). The stirrer comprised a 1 cm diameter by 43 cm long glass rod to which an 0.8 cm by 2.5 cm Teflon half moon paddle was fastened at one end. The other end was connected to a variable speed stirring motor (Talboys Instrument Corporation Model # 1075C). The stirring rod was rotated at 250 RPM.

The "blank" (nonelectrolysis cell) was stirred to simulate stirring in the electrolytic cell due to gas sparging. The one watt of heat from stirring resulted in the blank cell operating at 0.2 °C above ambient.

The temperature (± 0.1 °C) of the "blank" was recorded with a microprocessor thermometer (Omega HH21 Series) which was inserted through a 1/4" hole in the tank lid.

A cell that produced $6.3 \times 10^8 J$ of enthalpy of formation of increased binding energy hydrogen compounds was operated by BlackLight Power, Inc. (Malvern, PA), hereinafter "BLP Electrolytic Cell". The cell was equivalent to that described herein. The cell description is also given by Mills et al. [R. Mills, W. Good, and R. Shaubach, Fusion Technol. 25, 103 (1994)] except that it lacked the additional central cathode.

Thermacore Inc. (Lancaster, PA) operated an electrolytic cell described by Mills et al. [R. Mills, W. Good, and R. Shaubach, Fusion Technol. 25, 103 (1994)] herein after "Thermacore Electrolytic Cell". This cell had produced an enthalpy of formation of increased binding energy hydrogen compounds of $1.6 \times 10^9 J$ that exceeded the total input enthalpy given by the product of the electrolysis voltage and current over time by a factor greater than 8.

Idaho National Engineering Laboratory (INEL) operated [Jacox, M. G., Watts, K. D., "The Search for Excess Heat in the Mills Electrolytic Cell", Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho, 83415, January 7, 1993] a cell, hereinafter "INEL Electrolytic Cell", identical to the Thermacore Electrolytic Cell except that it was minus the central cathode and that the cell was wrapped in a one-inch layer of

80

urethane foam insulation about the cylindrical surface. The cell was operated in a pulsed power mode. A current of 10 amperes was passed through the cell for 0.2 seconds followed by 0.8 seconds of zero current for the current cycle. The cell voltage was about 2.4 volts, for an

5   average input power of 4.8 W. The electrolysis power average was 1.84 W, and the stirrer power was measured to be 0.3 W. Thus, the total average net input power was 2.14 W. The cell was operated at various resistance heater settings, and the temperature difference between the cell and the ambient as well as the heater power were measured. The

10   results of the excess power as a function of cell temperature with the cell operating in the pulsed power mode at 1 Hz with a cell voltage of 2.4 volts, a peak current of 10 amperes, and a duty cycle of 20 % showed that the excess power is temperature dependent for pulsed power operation, and the maximum excess power was 18 W for an input

15   electrolysis joule heating power of 2.14 W. Thus, the ratio of excess power to input electrolysis joule heating power was 850 %.

3.1.2   Quartz Gas Cell Hydrino Hydride Reactor

20   Hydrino hydride compounds were prepared in a vapor phase gas cell with a tungsten filament and *KI* as the catalyst according to Eqs. (3-5) and the reduction to hydrino hydride ion (Eq. (11)) occurred in the gas phase. The high temperature experimental gas cell shown in FIGURE 2 was used to produce hydrino hydride compounds. Hydrino atoms

25   were formed by hydrogen catalysis using potassium ions and hydrogen atoms in the gas phase.

        The experimental gas cell hydrino hydride reactor shown in FIGURE 2 comprised a quartz cell in the form of a quartz tube 2 five hundred (500) millimeters in length and fifty (50) millimeters in

30   diameter. The quartz cell formed a reaction vessel. One end of the cell was necked down and attached to a fifty (50) cubic centimeter catalyst reservoir 3. The other end of the cell was fitted with a Conflat style high vacuum flange that was mated to a Pyrex cap 5 with an identical Conflat style flange. A high vacuum seal was maintained with a Viton O-ring

35   and stainless steel clamp. The Pyrex cap 5 included five glass-to-metal tubes for the attachment of a gas inlet line 25 and gas outlet line 21, two

8 1

inlets 22 and 24 for electrical leads 6, and a port 23 for a lifting rod 26. One end of the pair of electrical leads was connected to a tungsten filament 1. The other end was connected to a Sorensen DCS 80-13 power supply 9 controlled by a custom built constant power controller. Lifting
5   rod 26 was adapted to lift a quartz plug 4 separating the catalyst reservoir 3 from the reaction vessel of cell 2. Optionally, the reactor further comprised a thermal radiation shield at the top of the cell to provide further insulation.

H_2 gas was supplied to the cell through the inlet 25 from a
10   compressed gas cylinder of ultra high purity hydrogen 11 controlled by hydrogen control valve 13. Helium gas was supplied to the cell through the same inlet 25 from a compressed gas cylinder of ultrahigh purity helium 12 controlled by helium control valve 15. The flow of helium and hydrogen to the cell is further controlled by mass flow controller 10,
15   mass flow controller valve 30, inlet valve 29, and mass flow controller bypass valve 31. Valve 31 was closed during filling of the cell. Excess gas was removed through the gas outlet 21 by a molecular drag pump 8 capable of reaching pressures of 10^{-4} torr controlled by vacuum pump valve 27 and outlet valve 28. Pressures were measured by a 0-1000
20   torr Baratron pressure gauge and a 0-100 torr Baratron pressure gauge 7. The filament 1 was 0.381 millimeters in diameter and two hundred (200) centimeters in length. The filament was suspended on a ceramic support to maintain its shape when heated. The filament was resistively heated using power supply 9. The power supply was capable of
25   delivering a constant power to the filament. The catalyst reservoir 3 was heated independently using a band heater 20, also powered by a constant power supply. The entire quartz cell was enclosed inside an insulation package comprised of Zircar AL-30 insulation 14. Several K type thermocouples were placed in the insulation to measure key
30   temperatures of the cell and insulation. The thermocouples were read with a multichannel computer data acquisition system.

The cell was operated under flow conditions with a total pressure of less than two (2) torr of hydrogen or control helium via mass flow controller 10. The filament was heated to a temperature in the range
35   from 1000-2000°C as calculated by its resistance. A preferred temperature was about 1400 °C. This created a "hot zone" within the

82

quartz tube of about 700-800 °C as well as causing atomization of the hydrogen gas. The catalyst reservoir was heated to a temperature of 700 °C to establish the vapor pressure of the catalyst. The quartz plug 4 separating the catalyst reservoir 3 from the reaction vessel 2 was

5 removed using the lifting rod 26 which was slid about 2 cm through the port 23. This introduced the vaporized catalyst into the "hot zone" containing the atomic hydrogen, and allowed the catalytic reaction to . occur.

As described above, a number of thermocouples were positioned to

10 measure the linear temperature gradient in the outside insulation. The gradient was measured for several known input powers over the experimental range with the catalyst valve closed. Helium supplied from the tank 12 and controlled by the valves 15, 29, 30, and 31, and flow controller 10 was flowed through the cell during the calibration

15 where the helium pressure and flow rates were identical to those of hydrogen in the experimental cases. The thermal gradient was determined to be linearly proportional to input power. Comparing an experimental gradient (catalyst valve open/hydrogen flowing) to the calibration gradient allowed the determination of the requisite power to

20 generate that gradient. In this way, calorimetry was performed on the cell to measure the heat output with a known input power. The data was recorded with a Macintosh based computer data acquisition system (PowerComputing PowerCenter Pro 180) and a National Instruments, Inc. NI-DAQ PCI-MIO-16XE-50 Data Acquisition Board.

25 Enthalpy of catalysis from the gas energy cell having a gaseous transition catalyst (K^+ / K^+) was observed with low pressure hydrogen in the presence of potassium iodide (KI) which was volatilized at the operating temperature of the cell. The enthalpy of formation of increased binding energy hydrogen compounds resulted in a steady

30 state power of about 15 watts that was observed from the quartz reaction vessel containing about 200 mtorr of KI when hydrogen was flowed over the hot tungsten filament. However, no excess enthalpy was observed when helium was flowed over the hot tungsten filament or when hydrogen was flowed over the hot tungsten filament with no KI

35 present in the cell.

83

In a separate experiment *RbI* or *RbCl* replaced *KI* as the gaseous transition catalyst according to Eq.(6), Eq.(7), and Eq.(8).

In two other embodiments, the experimental gas cell hydrino hydride reactor shown in FIGURE 2 comprised a titanium screen

5 (Belleville Wire Cloth Co., Inc.) filament of six titanium screen strips 3 cm wide and 30 cm in length or an 8 meter long coil of a three stand cable of 0.38 mm diameter nickel wire (99+% Alpha #10249) which replaced the tungsten filament 1. The titanium screen filament or nickel coil filament dissociator was treated with 0.6 M K_2CO_3/10% H_2O_2 before being

10 used in the quartz cell. The filament was suspended on Al_2O_3 cylindrical filament supports. The cell was operated at 800 °C when the filament temperature was from 1000 to 1200 °C, and *KBr* or *KI* catalyst was vaporized into the gas cell by heating the catalyst reservoir. Hydrogen was flowed through the cell at a steady state pressure of 1 torr.

15 In two other embodiments, a second 30 cm wide and 30 cm long nickel or titanium screen dissociator was wrapped inside the inner wall of the cell. The screen was heated by the titanium screen or nickel coil filament.

In another embodiment, the experimental gas cell hydrino hydride

20 reactor shown in FIGURE 2 comprised a Ni fiber mat (30.2 g, Fibrex from National Standard) inserted into the inside the quartz cell 2. The Ni mat was used as the H_2 dissociator which replaced the tungsten filament 1. The cell 2 and the catalyst reservoir 3 were each independently encased by split type clam shell furnaces (The Mellen Company) which replaced

25 the Zircar AL-30 insulation 14 and were capable of operating up to 1200 °C. The cell and catalyst reservoir were heated independently with their heaters to independently control the catalyst vapor pressure and the reaction temperature. The H_2 pressure was maintained at 2 torr at a flow rate of $\frac{0.5\ cm^3}{min}$. The Ni mat was maintained at 900 °C, and the *KI*

30 catalyst was maintained at 700 °C for 100 h.

3.1.3 Concentric Quartz Tubes Gas Cell Hydrino Hydride Reactor

Hydrino hydride compounds were prepared in a concentric quartz

35 tubes gas cell hydrino hydride reactor comprising a Ni screen dissociator

84

and *KI* as the catalyst. The experimental concentric quartz tubes gas cell hydrino hydride reactor is shown in FIGURE 3. The reactor cell comprised two concentric quartz tubes 401 and 402 of dimensions 1" OD X· 21" long and 3/4" OD X 24" long, respectively. The 1" OD tube was

5 closed at the bottom end with a thermowell 403 and the 3/4" OD tube was open at both ends. The quartz tubes were connected to Swagelok fittings 404 and 405 to provide a system capable of maintaining a vacuum. Two sets of external heaters 406 and 407 were used to control the temperature of the catalyst and the Ni fiber dissociator

10 independently. The heaters comprised Chrome Aluminum Iron heating elements imbedded in a high purity Al_2O_3 cement (The Mellen Company).

A Ni fiber mat dissociator -30.2 g (National Standard Company) 408 was placed in the 3/4" quartz tube 402. The Ni mat was pretreated in the cell by flowing H_2 (Scientific Grade- MGS Industries) from a H_2

15 source 409 at a rate of 20 cm³/min at a temperature of 900 °C for 24 h. The system was cooled by flowing He (Scientific Grade- MGS Industries) from a helium source 410 for 12 hours. *KI* catalyst - 10.3 g (99.0%, Alfa Aesar) 411 was placed at the bottom of the 1" OD quartz tube 401. H_2 was introduced in the annular space 412 of the two concentric tubes and

20 the product gas was pumped away via the 3/4" quartz tube using a vacuum pump 413. The total pressure was maintained at 2.0 torr. The Ni dissociator temperature was maintained around 950 °C (measured by a Type C thermocouple 414), and the catalyst temperature was maintained around 650°C (measured by a Type C thermocouple 415).

25 The reaction was stopped after 170 h, and the reactor was cooled in He for 12 hours before exposing the cell to atmospheric conditions.

3.1.4 Stainless Steel Gas Cell Hydrino Hydride Reactor

30 Hydrino hydride compounds were prepared in a stainless steel gas cell hydrino hydride reactor comprising a Ti screen dissociator and *KI* as the catalyst. The experimental stainless steel gas cell hydrino hydride reactor is shown in FIGURE 4. It comprised a 304-stainless steel cell 301 in the form of a tube having an internal cavity 317 having dimensions of

35 359 millimeters in length and 73 millimeters in diameter. The top end of the cell was welded to a high vacuum 4 5/8 inch bored through conflat

flange 318. The mating blank conflat flange 319 contained a single coaxial hole in which was welded a 1/4 inch diameter stainless steel tube 302 that was 100 cm in length. A silver plated copper gasket was placed between the two flanges. The two flanges are held together with 10

5 circumferential bolts. The bottom of the 1/4 inch tube 302 was flush with the bottom surface of the top flange 319. The tube 302 provided a passage for air to be removed from the cell and hydrogen to be supplied to the cell. The cell 301 was surrounded by four heaters 303, 304, 305, and 306. Concentric to the heaters was high temperature AL 30 Zircar

10 insulation 307. Each of the four heaters were individually thermostatically controlled.

Titanium screen was used as the dissociator and as a reactant to produce titanium hydrino hydride. The cylindrical wall of the cell 301 was lined with two layers of Ti screen 308. Before placing the titanium

15 dissociator in the cell 301. The titanium was reacted with an aqueous solution of 0.57 M K_2CO_3 and 3% H_2O_2 for ten minutes. The titanium screen was removed from the solution, and the reaction product was allowed to dry on the screen at room temperature. The screen was then baked at 200 °C for 12 hours. 71 grams of powdered KI 309 was poured

20 into the cell 301. The cell was sealed then continuously evacuated with a high vacuum turbo pump 310. The pressure gauge (Varian Convector, Pirrani type) 312 read 50 millitorr. The cell was heated by supplying power to the heaters 303, 304, 305, and 306. The power of the largest heater 305 was measured using a Clarke -Hess model 259 wattmeter.

25 Its 0 to 1 V analog output was fed to the DAS and recorded with the other signals. The temperature of the cell read with an Omega type K thermocouple with a type 97000 controller was then slowly increased over 2 hours to 300 °C. The pressure initially increased, then slowly dropped to 10 millitorr. The vacuum pump valve 311 was closed.

30 Hydrogen was supplied from tank 316 through regulator 315 to the valve 314. Hydrogen was slowly added by first filling the tube between valve 314 and valve 313 to 800 torr. Valve 313 was slowly opened to transfer the trapped hydrogen to the cell 301. This hydrogen transfer method was repeated until the pressure in the reactor climbed to 760

35 torr. The temperature of the cell was then slowly increased to 650 °C over 5 hours. The hydrogen valve 313 was closed. For the next two

hours, the vacuum valve 311 was slowly partially opened to bleed off the surplus hydrogen to maintain a pressure between 400 to 500 millitorr. During the next 17 hours the pressure climbed to 1 torr. The cell was then cooled and opened. About 5 grams of blue crystals were
5   observed to have formed in the bottom of the cell.

3.2   Novel Inorganic Hydride from a Potassium Carbonate Electrolytic Cell

10   ABSTRACT

A novel inorganic hydride compound $KH\,KHCO_3$ which is stable in water and comprises a high binding energy hydride ion was isolated following the electrolysis of a K_2CO_3 electrolyte. Inorganic hydride clusters
15    $K[KH\,KHCO_3]_n^+$ were identified by Time of Flight Secondary Ion Mass Spectroscopy. Moreover, the existence of a novel hydride ion has been determined using X-ray photoelectron spectroscopy, and proton nuclear magnetic resonance spectroscopy. Hydride ions with increased binding energies may be the basis of a high voltage battery for electric vehicles.
20

INTRODUCTION

     Evidence of the changing landscape for automobiles can be found in the recent increase in research into the next generation of automobiles.
25   But, the fact that there is no clear front-runner in the technological race to replace the internal combustion (IC) engine can be attested to by the divergent approaches taken by the major automobile companies. Programs include various approaches to hybrid vehicles, alternative fueled vehicles such as dual-fired engines that can run on gasoline or
30   compressed natural gas, and a natural gas-fired engine. Serious efforts are also being put into a number of alternative fuels such as ethanol, methanol, propane, and reformulated gasoline. To date, the most favored approach is an electric vehicle based on fuel cell technology or advanced battery technology such as sodium nickel chloride, nickel-metal hydride,
35   and lithium-ion batteries [I. Uehara, T. Sakai, H. Ishikawa, J. Alloy Comp., 253/254, (1997), pp. 635-641]. Although billions of dollars are being

spent to develop an alternative to the IC engine, there is no technology in sight that can match the specifications of IC engine system [New Scientist, April 15, (1995) pp. 32-35].

5   Fuel cells are attractive over the IC engine because they convert hydrogen to water at about 70% efficiency when running at about 20% below peak output [D. Mulholland, Defense News, "Powering the Future Military", March 8, 1999, pp. 1&34]. But, hydrogen is difficult and dangerous to store. Cryogenic, compressed gas, and metal hydride storage are the main options. In the case of cryogenic storage,

10   liquefaction of hydrogen requires an amount of electricity which is at least 30% of the lower heating value of liquid hydrogen [S. M. Aceves, G. D. Berry, and G. D. Rambach, Int. J. Hydrogen Energy, Vol. 23, No. 7, (1998), pp. 583-591]. Compressed hydrogen, and metal hydride storage are less viable since the former requires an unacceptable volume, and the

15   latter is heavy and has difficulties supplying hydrogen to match a load such as a fuel cell [S. M. Aceves, G. D. Berry, and G. D. Rambach, Int. J. Hydrogen Energy, Vol. 23, No. 7, (1998), pp. 583-591]. The main challenge with hydrogen as a replacement to gasoline is that a hydrogen production and refueling infrastructure would have to be built.

20   Hydrogen may be obtained by reforming fossil fuels. However, in practice fuel cell vehicles would probably achieve only 10 to 45 percent efficiency because the process of reforming fossil fuel into hydrogen and carbon dioxide requires energy [D. Mulholland, Defense News, "Powering the Future Military", March 8, 1999, pp. 1&34]. Presently, fuel cells are

25   also impractical due to their high cost as well as the lack of inexpensive reforming technology [J. Ball, The Wall Street Journal, "Auto Makers Are Racing to Market "Green" Cars Powered by Fuel Cells", March 15, 1999, p. 1].

       In contrast, batteries are attractive because they can be recharged

30   wherever electricity exists which is ubiquitous. The cost of mobile energy from a battery powered car may be less than that from a fossil fuel powered car. For example, the cost of energy per mile of a nickel metal hydride battery powered car is 25% of that of a IC powered car ["Advanced Automotive Technology: Visions of a Super-Efficient Family

35   Car", National Technical Information Service, US Department of Commerce, US Office of Technology Assessment, Washington, DC PB96-

88

109202, September 1995]. But, current battery technology is trying to compete with something that it has little chance of imitating. Whichever battery technology proves to be superior, no known electric power plant will match the versatility and power of an internal combustion engine. A

5 typical IC engine yields more than 10,000 watt-hours of energy per kilogram of fuel, while the most promising battery technology yields 200 watt-hours per kilogram [New Scientist, April 15, (1995) pp. 32-35].

A high voltage battery would have the advantages of much greater power and much higher energy density. The limitations of battery

10 chemistry may be attributed to the binding energy of the anion of the oxidant. For example, the 2 volts provided by a lead acid cell is limited by the 1.46 eV electron affinity of the oxide anion of the oxidant PbO_2. An increase in the oxidation state of lead such as $Pb^{2+} \rightarrow Pb^{3+} \rightarrow Pb^{4+}$ is possible in a plasma. Further oxidation of lead could also be achieved in

15 theory by electrochemical charging. But, higher lead oxidation states are not achievable because the oxide anion required to form a neutral compound would undergo oxidation by the highly oxidized lead cation. An anion with an extraordinary binding energy is required for a high voltage battery. One of the highest voltage batteries known is the lithium

20 fluoride battery with a voltage of about 6 volts. The voltage can be attributed to the higher binding energy of the fluoride ion. The electron affinity of halogens increases from the bottom of the Group VII elements to the top. Hydride ion may be considered a halide since it possess the same electronic structure. And, according to the binding energy trend, it

25 should have a high binding energy. However, the binding energy is only 0.75 eV which is much lower than the 3.4 eV binding energy of a fluoride ion.

An inorganic hydride compound having the formula $KH\,KHCO_3$ was isolated from an aqueous K_2CO_3 electrolytic cell reactor. Inorganic

30 hydride clusters $K[KH\,KHCO_3]_n^+$ were identified by Time of Flight Secondary Ion Mass Spectroscopy (ToF-SIMS). A hydride ion with a binding energy of 22.8 eV has been observed by X-ray photoelectron spectroscopy (XPS) having upfield shifted solid state magic-angle spinning proton nuclear magnetic resonance (^1H MAS NMR) peaks.

35 Moreover, a polymeric structure is indicated by Fourier transform infrared (FTIR) spectroscopy. The discovery of a novel hydride ion with

a high binding energy has implications for a new field of hydride chemistry with applications such as a high voltage battery. Such extremely stable hydride ions may stabilize positively charged ions in an unprecedented highly charged state. A battery may be possible having

5   projected specifications that surpass those of the internal combustion engine.

EXPERIMENTAL

10 Synthesis

An electrolytic cell comprising a K_2CO_3 electrolyte, a nickel wire cathode, and platinized titanium anodes was used to synthesize the KH $KHCO_3$ sample [R. Mills, W. Good, and R. Shaubach, Fusion Technol. 25, 103 (1994)]. Briefly, the cell vessel comprised a 10 gallon (33 in. x 15

15 in.) Nalgene tank. An outer cathode comprised 5000 meters of 0.5 mm diameter clean, cold drawn nickel wire [NI 200 0.0197", HTN36NOAG1, A-1 Wire Tech, Inc., 840-39th Ave., Rockford, Illinois, 61109] wound on a polyethylene cylindrical support. A central cathode comprised 5000 meters of the nickel wire wound in a toroidal shape. The central cathode

20 was inserted into a cylindrical, perforated polyethylene container that was placed inside the outer cathode with an anode array between the central and outer cathodes. The anode comprised an array of 15 platinized titanium anodes [Ten - Engelhard Pt/Ti mesh 1.6" x 8" with one 3/4" by 7" stem attached to the 1.6" side plated with 100 U series 3000;

25 and 5 - Engelhard 1" diameter x 8" length titanium tubes with one 3/4" x 7" stem affixed to the interior of one end and plated with 100 U Pt series 3000]. Before assembly, the anode array was cleaned in 3 M HCl for 5 minutes and rinsed with distilled water. The cathode was cleaned by placing it in a tank of 0.57 M K_2CO_3/3% H_2O_2 for 6 hours and then rinsing

30 it with distilled water. The anode was placed in the support between the central and outer cathodes, and the electrode assembly was placed in the tank containing electrolyte. The electrolyte solution comprised 28 liters of 0.57 M K_2CO_3 (Alfa K_2CO_3 99%). Electrolysis was performed at 20 amps constant current with a constant current (± 0.02%) power supply.

35 Samples were isolated from the electrolytic cell by concentrating the K_2CO_3 electrolyte about six fold using a rotary evaporator at 50 °C

90

until a yellow white polymeric suspension formed. Precipitated crystals of the suspension were then grown over three weeks by allowing the saturated solution to stand in a sealed round bottom flask at 25°C. Control samples utilized in the following experiments contained K_2CO_3

5   (99%), $KHCO_3$ (99.99%), HNO_3 (99.99%), and KH (99%).

ToF-SIMS Characterization

The crystalline samples were sprinkled onto the surface of double-sided adhesive tapes and characterized using a Physical Electronics TFS-

10   2000 ToF-SIMS instrument. The primary ion gun utilized a $^{69}Ga^+$ liquid metal source. In order to remove surface contaminants and expose a fresh surface, the samples were sputter cleaned for 30 seconds using a $40\mu m$ X $40\mu m$ raster. The aperture setting was 3, and the ion current was 600 pA resulting in a total ion dose of 10^{15} $ions/cm^2$.

15   During acquisition, the ion gun was operated using a bunched (pulse width 4 ns bunched to 1 ns) 15 kV beam [Microsc. Microanal. Microstruct., Vol. 3, 1, (1992); For recent specifications see PHI Trift II, ToF-SIMS Technical Brochure, Eden Prairie, MN 55344]. The total ion dose was 10^{12} $ions/cm^2$. Charge neutralization was active, and the post

20   accelerating voltage was 8000 V. Three different regions on each sample of $(12\mu m)^2$, $(18\mu m)^2$, and $(25\mu m)^2$ were analyzed. The positive and negative SIMS spectra were acquired. Representative post sputtering data is reported.

25   ## XPS Characterization

A series of XPS analyses were made on the crystalline samples using a Scienta 300 XPS Spectrometer. The fixed analyzer transmission mode and the sweep acquisition mode were used. The step energy in the survey scan was $0.5\,eV$, and the step energy in the high resolution scan

30   was $0.15\,eV$. In the survey scan, the time per step was 0.4 seconds, and the number of sweeps was 4. In the high resolution scan, the time per step was 0.3 seconds, and the number of sweeps was 30. $C\,1s$ at $284.6\,eV$ was used as the internal standard.

35   ## NMR Spectroscopy

^1H MAS NMR was performed on the crystalline samples. The data were obtained on a custom built spectrometer operating with a Nicolet 1280 computer. Final pulse generation was from a tuned Henry radio amplifier. The ^1H NMR frequency was 270.6196 MHz. A 2 μsec pulse corresponding to a 15° pulse length and a 3 second recycle delay were used. The window was ±31 kHz. The spin speed was 4.5 kHz. The number of scans was 1000. Chemical shifts were referenced to external TMS. The offset was 1527.12 Hz, and the magnetic flux was 6.357 T.

10   FTIR Spectroscopy

Samples were transferred to an infrared transmitting substrate and analyzed by FTIR spectroscopy using a Nicolet Magna 550 FTIR Spectrometer with a NicPlan FTIR microscope. The number of scans was 500 for both the sample and background. The number of background scans was 500. The resolution was 8.000. A dry air purge was applied.

RESULTS AND DISCUSSION

ToF-SIMS

20   The positive ToF-SIMS spectrum obtained from the $KHCO_3$ control is shown in FIGURES 96 and 97. Moreover, the positive ToF-SIMS of a sample isolated from the electrolytic cell is shown in FIGURES 98 and 99. The respective hydride compounds and mass assignments appear in TABLE 3.11.1. In both the control and electrolytic samples, the positive ion spectrum are dominated by the K^+ ion. Two series of positive ions $\{K[K_2CO_3]_n^+$ $m/z = (39+138n)$ and $K_2OH[K_2CO_3]_n^+$ $m/z = (95+138n)\}$ are observed in the $KHCO_3$ control. Other peaks containing potassium include KC^+, $K_xO_y^+$, $K_xO_yH_z^+$, KCO^+, and K_2^+. However, in the electrolytic cell sample, three new series of positive ions are observed at

30    $\{K[KH\,KHCO_3]_n^+$ $m/z = (39+140n)$, $K_2OH[KH\,KHCO_3]_n^+$ $m/z = (95+140n)$, and $K_3O[KH\,KHCO_3]_n^+$ $m/z = (133+140n)\}$. These ions correspond to inorganic clusters containing novel hydride combinations (i.e. $KH\,KHCO_3$ units plus other positive fragments).

The comparison of the positive ToF-SIMS spectrum of the $KHCO_3$ control with the electrolytic cell sample shown in FIGURES 96-97 and 98-

92

99, respectively, demonstrates that the $^{39}K^+$ peak of the electrolytic cell sample may saturate the detector and give rise to a peak that is atypical of the natural abundance of ^{41}K. The natural abundance of ^{41}K is 6.7%; whereas, the observed ^{41}K abundance from the electrolytic cell sample is
5   57%. This atypical abundance was also confirmed using ESIToFMS [R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 1999 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com]. The high resolution mass assignment of the $m/z = 41$ peak of the electrolytic sample was consistent with ^{41}K, and no peak was
10   observed at $m/z = 42.98$ ruling out $^{41}KH_2^+$. Moreover, the natural abundance of ^{41}K was observed in the positive ToF-SIMS spectra of $KHCO_3$, KNO_3, and KI standards that were obtained with an ion current such that the ^{39}K peak intensity was an order of magnitude higher than that given for the electrolytic cell sample. The saturation of the ^{39}K peak
15   of the positive ToF-SIMS spectrum by the electrolytic cell sample is indicative of a unique crystalline matrix [*Practical Surface Analysis*, 2nd Edition, Volume 2, Ion and Neutral Spectroscopy, D. Briggs, M. P. Seah (Editors), Wiley & Sons, New York, (1992)].

20   TABLE 3.11.1. The respective hydride compounds and mass assignments (m/z) of the positive ToF-SIMS of an electrolytic cell sample.

Hydrino Hydride Compound or Fragment	Nominal Mass m/z	Observed m/z	Calculated m/z	Difference Between Observed and Calculated m/z
KH	40	39.97	39.971535	0.0015
K_2H	79	78.940	78.935245	0.004
$(KH)_2$	80	79.942	79.94307	0.001
$KHKOH_2$	97	96.945	96.945805	0.0008
$KH_2(KH)_2$	121	120.925	120.92243	0.003
$KH\,KHCO_2$	124	123.925	123.93289	0.008
KH_2KHO_4	145	144.92	144.930535	0.010
$K(KOH)_2$	151	150.90	150.8966	0.003
$KH(KOH)_2$	152	151.90	151.904425	0.004

93

$KH_2(KOH)_2$	153	152.90	152.91225	0.012
$K[KH\ KHCO_3]$	179	178.89	178.8915	0.001
$KCO(KH)_3$	187	186.87	186.873225	0.003
$K_2OHKHKOH$	191	190.87	190.868135	0.002
$KH_2KOHKHKOH$	193	192.89	192.883785	0.006
$K_3O(H_2O)_4$	205	204.92	204.92828	0.008
$K_2OH[KH\ KHCO_3]$	235	234.86	234.857955	0.002
$K[H_2CO_4\ KH\ KHCO_3]$	257	256.89	256.8868	0.003
$K_3O[KH\ KHCO_3]$	273	272.81	272.81384	0.004
$[KH_2CO_3]_3$	303	302.88	302.89227	0.012
$K[KH\ KHCO_3K_2CO_3]$	317	316.80	316.80366	0.004
$K[KH\ KHCO_3]_2$	319	318.82	318.81931	0.001
$KH_2[KH\ KOH]_3$	329	328.80	328.7933	0.007
$KOH_2[KH\ KHCO_3]_2$	337	336.81	336.82987	0.020
$KH\ KO_2$ $[KH\ KHCO_3][KHCO_3]$	351	350.81	350.80913	0.001
$KKHK_2CO_3$ $[KH\ KHCO_3]$	357	356.77	356.775195	0.005
$KKH[KH\ KHCO_3]_2$	359	358.78	358.790845	0.011
$K_2OH[KH\ KHCO_3]_2$	375	374.78	374.785755	0.005
$K_2OH[KHKOH]_2$ $[KHCO_3]$	387	386.75	386.76238	0.012
$KKH_3KH_5[KH\ KHCO_3]_2$	405	404.79	404.80933	0.019
$K_3O[K_2CO_3]$ $[KH\ KHCO_3]$ or $K[KH\ KOH(K_2CO_3)_2]$	411	410.75	410.72599	0.024
$K_3O[KH\ KHCO_3]_2$	413	412.74	412.74164	0.002
$K\begin{bmatrix} KH\ KOH \\ (KH\ KHCO_3)_2 \end{bmatrix}$	415	414.74	414.75729	0.017
KH_2OKHCO_3 $[KH\ KHCO_3]_2$	437	436.81	436.786135	0.024
$KKHKCO_2[KH\ KHCO_3]_2$	442	441.74	441.744375	0.004

$K[KH\ KHCO_3]_3$	459	458.72	458.74711	0.027
$H[KH\ KOH]_2[K_2CO_3]_2$ or $K_4O_2H[KH\ KHCO_3]_2$	469	468.70	468.708085	0.008
$K[K_2CO_3][KHCO_3]_3$	477	476.72	476.744655	0.025
$K_2OH[KH\ KHCO_3]_3$	515	514.72	514.713555	0.006
$K_3O[KH\ KHCO_3]_3$	553	552.67	552.66944	0.001
$K[KH\ KHCO_3]_4$	599	598.65	598.67491	0.025
$K_2OH[KH\ KHCO_3]_4$	655	654.65	654.641355	0.009
$K_3O[KH\ KHCO_3]_4$	693	692.60	692.59724	0.003
$K[KH\ KHCO_3]_5$	739	738.65	738.60271	0.047
$K_3O[KH\ KHCO_3]_5$	833	832.50	832.52504	0.025
$K[KH\ KHCO_3]_6$	879	878.50	878.53051	0.031
$K_3O[KH\ KHCO_3]_6$	973	972.50	972.45284	0.047

The negative ion ToF-SIMS of the electrolytic cell sample was dominated by H^-, O^-, and OH^- peaks. A series of nonhydride containing negative ions $\{ KCO_3[K_2CO_3]_n^-\ \ m/z = (99 + 138n) \}$ was also present which

5 implies that the hydride is lost with the proton during fragmentation of the compound $KH\ KHCO_3$.

XPS

A survey spectrum was obtained over the region $E_b = 0\ eV$ to $1200\ eV$.

10 The primary element peaks allowed for the determination of all of the elements present in each sample isolated from the K_2CO_3 electrolyte. The survey spectrum also detected shifts in the binding energies of the elements which had implications to the identity of the compound containing the elements. A high resolution XPS spectrum was also

15 obtained of the low binding energy region ($E_b = 0\ eV$ to $100\ eV$) to determine the presence of novel XPS peaks.

No elements were present in the survey scans which can be assigned to peaks in the low binding energy region with the exception of a small variable contaminant of sodium at 63 eV and 31 eV, potassium at

20 16.2 eV and 32.1 eV, and oxygen at 23 eV. Accordingly, any other peaks

in this region must be due to novel species. The $K\,3s$ and $K\,3p$ are shown in Figure 100 at 16.2 eV and 32.1 eV, respectively. A weak $Na\,2s$ is observed at 63 eV. The $O\,2s$ which is weak compared to the potassium peaks of K_2CO_3 is typically present at 23 eV, but is broad or obscured in

5   FIGURE 100. Peaks centered at 22.8 eV and 38.8 eV which do not correspond to any other primary element peaks were observed. The intensity and shift match shifted $K\,3s$ and $K\,3p$. Hydrogen is the only element which does not have primary element peaks; thus, it is the only candidate to produce the shifted peaks. These peaks may be shifted by a

10   highly binding hydride ion with a binding energy of 22.8 eV that bonds to potassium $K\,3p$ and shifts the peak to this energy. In this case, the $K\,3s$ is similarly shifted. These peaks were not present in the case of the XPS of matching samples isolated from an identical electrolytic cell except that Na_2CO_3 replaced K_2CO_3 as the electrolyte.

15   A novel hydride ion having extraordinary chemical properties given by Mills [R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 1999 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com] is predicted to form by the reaction of an electron with a hydrino (Eq. (71)), a hydrogen atom having a

20   binding energy given by

$$Binding\ Energy = \frac{13.6\ eV}{\left(\dfrac{1}{p}\right)^2} \tag{70}$$

where p is an integer greater than 1, designated as $H\left[\dfrac{a_H}{p}\right]$ where a_H is

the radius of the hydrogen atom. The resulting hydride ion is referred to as a hydrino hydride ion, designated as $H^-(1/p)$.
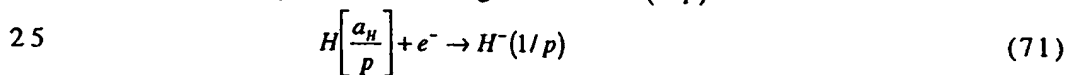
25    $$H\left[\frac{a_H}{p}\right] + e^- \rightarrow H^-(1/p) \tag{71}$$

The hydrino hydride ion is distinguished from an ordinary hydride ion having a binding energy of 0.8 eV. The latter is hereafter referred to as "ordinary hydride ion". The hydrino hydride ion is predicted [R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 1999

30   Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com] to comprise a hydrogen nucleus and two indistinguishable electrons at a binding energy according to the following formula:

$$Binding\ Energy = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\dfrac{1+\sqrt{s(s+1)}}{p}\right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3}\left(1+\frac{2^2}{\left[\dfrac{1+\sqrt{s(s+1)}}{p}\right]^3}\right) \qquad (72)$$

where p is an integer greater than one, $s = 1/2$, π is pi, $\hbar$ is Planck's constant bar, μ_o is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_o is the Bohr radius, and e is the elementary charge. The ionic radius is

$$r_1 = \frac{a_0}{p}\left(1+\sqrt{s(s+1)}\right);\ s=\frac{1}{2} \qquad (73)$$

From Eq. (73), the radius of the hydrino hydride ion $H^-(1/p)$; $p = $ integer is $\frac{1}{p}$ that of ordinary hydride ion, $H^-(1/1)$. The XPS peaks centered at

$22.8\,eV$ and $38.8\,eV$ are assigned to shifted $K\,3s$ and $K\,3p$. The anion does not correspond to any other primary element peaks; thus, it may correspond to the $H^-(n=1/6)\,E_b = 22.8\,eV$ hydride ion predicted by Mills [R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 1999 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com] where E_b is the predicted binding energy.

Hydrinos are predicted to form by reacting an ordinary hydrogen atom with a catalyst having a net enthalpy of reaction of about

$$m \cdot 27.21\,eV \qquad (74)$$

where m is an integer [R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 1999 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com]. This catalysis releases energy from the hydrogen atom with a commensurate decrease in size of the hydrogen atom, $r_a = na_H$. For example, the catalysis of $H(n=1)$ to $H(n=1/2)$ releases $40.8\,eV$, and the hydrogen radius decreases from a_H to $\frac{1}{2}a_H$. One such catalytic system involves potassium. The

second ionization energy of potassium is $31.63\,eV$; and K^+ releases $4.34\,eV$ when it is reduced to K. The combination of reactions K^+ to K^{2+} and K^+ to K, then, has a net enthalpy of reaction of $27.28\,eV$, which is equivalent to $m = 1$ in Eq. (74).

$$27.28\,eV + K^+ + K^+ + H\left[\frac{a_H}{p}\right] \to K + K^{2+} + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]\,X\,13.6\,eV \qquad (75)$$

97

$$K + K^{2+} \rightarrow K^+ + K^+ + 27.28\ eV \qquad (76)$$

The overall reaction is

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2]\ X\ 13.6\ eV \qquad (77)$$

The energy given off during catalysis is much greater than the energy
lost to the catalyst. The energy released is large as compared to
conventional chemical reactions. For example, when hydrogen and
oxygen gases undergo combustion to form water

$$H_2\ (g) + \frac{1}{2}O_2\ (g) \rightarrow H_2O\ (l) \qquad (78)$$
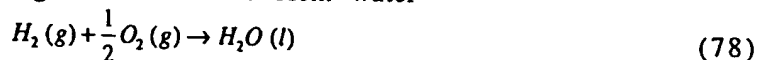
the known formation enthalpy of water is $\Delta H_f = -286\ kJ\ /\ mole$ or 1.48 eV
per hydrogen atom. By contrast, each ordinary hydrogen atom $(n=1)$
catalysis releases a net of $40.8\ eV$. The exothermic reactions Eq. (75-77),
Eq. (71) and the enthalpy of formation of $KH\ KHCO_3$ could explain the
observation of excess enthalpy of $1.6\ X\ 10^9\ J$ that exceeded the total input
enthalpy given by the product of the electrolysis voltage and current
over time by a factor greater than 8 [R. Mills, W. Good, and R. Shaubach,
Fusion Technol. 25, 103 (1994)].

XPS further confirmed the ToF-SIMS data by showing shifts of the
primary elements. The splitting of the principle peaks of the survey XPS
spectrum is indicative of multiple forms of bonding involving the atom of
each split peak. For example, the XPS survey spectrum shown in FIGURE
101 shows extraordinary potassium and oxygen peak shifts. All of the
potassium primary peaks are shifted to about the same extent as that of
the $K\ 3s$ and $K\ 3p$. In addition, extraordinary $O\ 1s$ peaks of the
electrolytic cell sample were observed at $537.5\ eV$ and $547.8\ eV$; whereas, a
single $O\ 1s$ was observed in the XPS spectrum of K_2CO_3 at $532.0\ eV$. The
results are not due to uniform charging as the internal standard $C\ 1s$
remains the same at $284.6\ eV$. The results are not due to differential
charging because the peak shapes of carbon and oxygen are normal, and
no tailing of these peaks was observed. The binding energies of the
K_2CO_3 control and an electrolytic cell sample are shown in TABLE 3.11.2.
The range of binding energies from the literature [C. D. Wagner, W. M.
Riggs, L. E. Davis, J. F. Moulder, G. E. Mulilenberg (Editor), *Handbook of X-
ray Photoelectron Spectroscopy*, Perkin-Elmer Corp., Eden Prairie,
Minnesota, (1997)] for the peaks of interest are given in the final row of

TABLE 3.11.2. The $K3p$, $K3s$, $K2p_{3/2}$, $K2p_{1/2}$, and $K2s$ XPS peaks and the $O1s$ XPS peaks shifted to an extent greater than those of known compounds may correspond to and identify $KHKHCO_3$.

5   TABLE 3.11.2. The binding energies of XPS peaks of K_2CO_3 and an electrolytic cell sample.

XPS #	$C1s$ (eV)	$O1s$ (eV)	$K3p$ (eV)	$K3s$ (eV)	$K2p_3$ (eV)	$K2p_1$ (eV)	$K2s$ (eV)
K_2CO_3	288.4	532.0	18	34	292.4	295.2	376.7
Electrolytic Cell Sample	288.5	530.4 537.5 547.8	16.2 22.8	32.1 38.8	291.5 298.5	293.7 300.4	376.6 382.6
Min Max	280.5 293	529 535			292 293.2		

NMR

The signal intensities of the ^1H MAS NMR spectrum of the K_2CO_3
10   reference were relatively low. It contained a water peak at 1.208 ppm, a peak at 5.604 ppm, and very broad weak peaks at 13.2 ppm, and 16.3 ppm. The ^1H MAS NMR spectrum of the $KHCO_3$ reference contained a large peak at 4.745 with a small shoulder at 5.150 ppm, a broad peak at 13.203 ppm, and small peak at 1.2 ppm.
15   The ^1H MAS NMR spectra of an electrolytic cell sample is shown in FIGURE 102. The peak assignments are given in TABLE 3.11.3. The reproducible peaks assigned to $KHKHCO_3$ in TABLE 3.11.3 were not present in the controls except for the peak assigned to water at +5.066 ppm. The novel peaks could not be assigned to hydrocarbons.
20   Hydrocarbons were not present in the electrolytic cell sample based on the TOFSIMS spectrum and FTIR spectra which were also obtained (see below). The novel peaks without identifying assignment are consistent with $KHKHCO_3$. The NMR peaks of the hydride ion of potassium hydride were observed at 1.192 ppm and 0.782 ppm relative to TMS. The upfield
25   peaks of FIGURE 102 are assigned to novel hydride ion ($KH-$) in different environments. The down field peaks are assigned to the proton of the

potassium hydrogen carbonate species in different chemical environments $(-KHCO_3)$.

TABLE 3.11.3. The NMR peaks of an electrolytic cell sample with their assignments.

Peak at Shift (ppm)	Assignment
+34.54	side band of +17.163 peak
+22.27	side band of +5.066 peak
+17.163	$KH\,KHCO_3$
+10.91	$KH\,KHCO_3$
+8.456	$KH\,KHCO_3$
+7.50	$KH\,KHCO_3$
+5.066	H_2O
+1.830	$KH\,KHCO_3$
-0.59	side band of +17.163 peak
-12.05	$KH\,KHCO_3$ [a]
-15.45	$KH\,KHCO_3$

[a] small shoulder is observed on the -12.05 peak which is the side band of the +5.066 peak

FTIR

The FTIR spectra of K_2CO_3 (99%) and $KHCO_3$ (99.99%) were compared with that of an electrolytic cell sample. A spectrum of a mixture of the bicarbonate and the carbonate was produced by digitally adding the two reference spectra. The two standards alone and the mixed standards were compared with that of the electrolytic cell sample. From the comparison, it was determined that the electrolytic cell sample contained potassium carbonate but did not contain potassium bicarbonate. The unknown component could be a bicarbonate other than potassium bicarbonate. The spectrum of potassium carbonate was digitally subtracted from the spectrum of the electrolytic cell sample.

100

Several bands were observed including bands in the $1400-1600\, cm^{-1}$
region. Some organic nitrogen compounds (e.g. acrylamides,
pyrolidinones) have strong bands in the region $1660\, cm^{-1}$ [D. Lin-Vien, N. B.
Colthup, W. G. Fateley, J. G. Grassellic, *The Handbook of Infrared and*
5 *Raman Characteristic Frequencies of Organic Molecules*, Academic Press,
Inc., (1991)]. However, the lack of any detectable $C-H$ bands
$(\approx 2800-3000\, cm^{-1})$ and the bands present in the 700 to $1100\, cm^{-1}$ region
indicate an inorganic material [R. A. Nyquist and R. O. Kagel, (Editors),
Infrared Spectra of Inorganic Compounds, Academic Press, New York,
10 (1971)]. Peaks that are not assignable to potassium carbonate were
observed at 3294, 3077, 2883, $1100\, cm^{-1}$, 2450, 1660, 1500, 1456, 1423, 1300,
1154, 1023, 846, 761, and $669\, cm^{-1}$.

The overlap FTIR spectrum of the electrolytic cell sample and the
FTIR spectrum of the reference potassium carbonate appears in FIGURE
15 103. In the 700 to $2500\, cm^{-1}$ region, the peaks of the electrolytic cell
sample closely resemble those of potassium carbonate, but they are
shifted about $50\, cm^{-1}$ to lower frequencies. The shifts are similar to those
observed by replacing potassium (K_2CO_3) with rubidium (Rb_2CO_3) as
demonstrated by comparing their IR spectra [M. H. Brooker, J. B. Bates,
20 *Spectrochimica Acta*, Vol. 30A, (1994), pp. 2211-2220]. The shifted
peaks may be explained by a polymeric structure for the compound
$KH\, KHCO_3$ identified by ToF-SIMS, XPS, and NMR.

Further Analytical Tests

25   X-ray diffraction (XRD), elemental analysis using inductively
coupled plasma (ICP), and Raman spectroscopy were also performed on
the electrolytic sample [R. Mills, *The Grand Unified Theory of Classical
Quantum Mechanics*, January 1999 Edition, BlackLight Power, Inc.,
Cranbury, New Jersey, Distributed by Amazon.com]. The XRD data
30 indicated that the diffraction pattern of the electrolytic cell sample does
not match that of either KH, $KHCO_3$, K_2CO_3, or KOH. The elemental
analysis supports $KH\, KHCO_3$. In addition to the known Raman peaks of
$KHCO_3$ and a small peak assignable to K_2CO_3, unidentified peaks at
$1685\, cm^{-1}$ and $835\, cm^{-1}$ were present. Work in progress [R. Mills, *The Grand
35 Unified Theory of Classical Quantum Mechanics*, January 1999 Edition,
BlackLight Power, Inc., Cranbury, New Jersey, Distributed by

101

Amazon.com] demonstrates that $KH\,KHCO_3$ may also be formed by a reaction of gaseous KI with atomic hydrogen in the presence of K_2CO_3. In addition to the previous analytical studies, the fragment $KK_2CO_3^+$ corresponding to $KH\,KHCO_3$ was observed by electrospray ionization time of flight mass spectroscopy as a chromatographic peak on a C18 liquid chromatography column typically used to separate organic compounds. No chromatographic peaks were observed in the case of inorganic compound controls KI, $KHCO_3$, K_2CO_3, and KOH

10   DISCUSSION

Alkali and alkaline earth hydrides react violently with water to release hydrogen gas which subsequently ignites due to the exothermic reaction with water. Typically metal hydrides decompose upon heating at a temperature well below the melting point of the parent metal. These saline hydrides, so called because of their saltlike or ionic character, are the monohydrides of the alkali metals and the dihydrides of the alkaline-earth metals, with the exception of beryllium. BeH_2 appears to be a hydride with bridge type bonding rather than an ionic hydride. Highly polymerized molecules held together by hydrogen-bridge bonding is exhibited by boron hydrides and aluminum hydride. Based on the known structures of these hydrides, the ToF-SIMS hydride clusters such as $K[KH\,KHCO_3]_n^+$, the XPS peaks observed at $22.8\,eV$ and $33.8\,eV$, upfield NMR peaks assigned to hydride ion, and the shifted FTIR peaks, the present novel hydride compound may be a polymer, $[KH\,KHCO_3]_n$, with a structural formula which is similar to boron and aluminum hydrides. The reported novel compound appeared polymeric in the concentrated electrolytic solution and in distilled water. $[KH\,KHCO_3]_n$ is extraordinarily stable in water; whereas, potassium hydride reacts violently with water.

As an example of the structures of this compound, the $K[KH\,KHCO_3]_n^+$ $m/z = (39 + 140n)$ series of fragment peaks is tentatively assigned to novel hydride bridged or linear potassium bicarbonate compounds having a general formula such as $[KHKHCO_3]_n$ $n = 1,2,3....$ General structural formulas may be

102

$$\left[\begin{array}{c} K^+ \underset{\overset{\diagdown}{H^-}}{\overset{\diagup HCO_3^-}{\diagdown}} K^+ \end{array} \right]_n$$

and
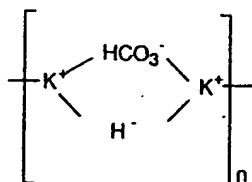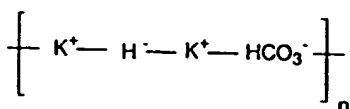
$$\left[K^+ - H^- - K^+ - HCO_3^- \right]_n$$

Liquid chromatography/ESIToFMS studies are in progress to support the
5   polymer assignment.

The observation of inorganic hydride fragments such as
$K[KH\,KHCO_3]^+$ in the positive ToF-SIMS spectra of samples isolated from
the electrolyte following acidification indicates the stability of the novel
potassium hydride potassium bicarbonate compound [R. Mills, *The Grand*
10   *Unified Theory of Classical Quantum Mechanics*, January 1999 Edition,
BlackLight Power, Inc., Cranbury, New Jersey, Distributed by
Amazon.com]. The electrolyte was acidified with HNO_3 to $pH = 2$ and
boiled to dryness to prepare samples to determine whether $KH\,KHCO_3$
was reactive under these conditions. Ordinarily no K_2CO_3 would be
15   present, and the sample would be converted to KNO_3. Crystals were
isolated by dissolving the dried crystals in water, concentrating the
solution, and allowing crystals to precipitate. ToF-SIMS was performed
on these crystals. The positive spectrum contained elements of the series
of inorganic hydride clusters $\{ K[KH\,KHCO_3]_n^+ \quad m/z = (39 + 140n),$
20   $K_2OH[KH\,KHCO_3]_n^+ \quad m/z = (95 + 140n),$ and $K_3O[KH\,KHCO_3]_n^+ \quad m/z = (133 + 140n) \}$
that were observed in the positive ToF-SIMS spectrum of the electrolytic
cell sample as discussed in the ToF-SIMS Results Section and given in
FIGURES 98-99 and TABLE 3.11.1. The presence of bicarbonate carbon
($C\,1s \cong 289.5\,eV$) was observed in the XPS of the sample from the HNO_3
25   acidified electrolyte. In addition, fragments of compounds formed by the
displacement of hydrogen carbonate by nitrate were observed [R. Mills,
The Grand Unified Theory of Classical Quantum Mechanics, January 1999
Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by
Amazon.com]. A general structural formula for the reaction maybe

103

$$\left[K^+ \!-\!\! H^- \!-\! K^+ \!-\! HCO_3^- \right]_n \quad \xrightarrow{\;NO_3^-\;}$$

$$\left[K^+ \!-\! H^- \!-\! K^+ \!-\! NO_3^- \right]_n \quad \text{or}$$

$$\left[K^+ \underset{H^-}{\overset{NO_3^-}{\diagdown\;\diagup}} K^+ \right]_n \quad + \; nHCO_3^-$$

$$(79)$$
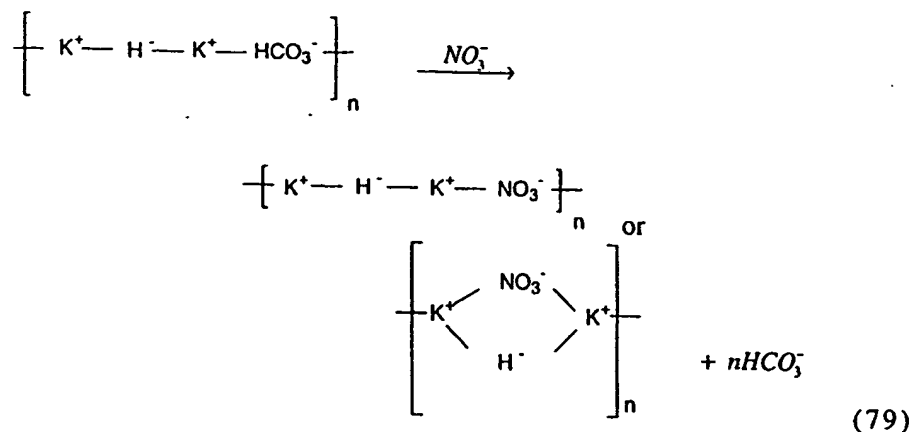
During acidification of the K_2CO_3 electrolyte the pH repetitively
increased from 3 to 9 at which time additional acid was added with
carbon dioxide release. The increase in pH (release of base by the
titration reactant) was dependent on the temperature and concentration
of the solution. A reaction consistent with this observation is the
displacement reaction of NO_3^- for HCO_3^{2-} as given by Eq. (79).

CONCLUSION

The ToF-SIMS, XPS, and NMR results confirm the identification of
$KH\,KHCO_3$ with a new state of hydride ion. The chemical structure and
properties of this compound having a hydride ion with a high binding
energy are indicative of a new field of hydride chemistry. The novel
hydride ion may combine with other cations such as other alkali cations
and alkaline earth, rare earth, and transition element cations. Thousands
of novel compounds may be synthesized with extraordinary properties
relative to the corresponding compounds having ordinary hydride ions.
These novel compounds may have a breath of applications. For example,
a high voltage battery according to the hydride binding energy of $22.8\,eV$
observed by XPS may be possible having projected specifications that
surpass those of the internal combustion engine.

104

3.3   Synthesis and Characterization of Potassium Iodo Hydride

ABSTRACT

5   A novel inorganic hydride compound *KHI* which comprises a high binding
energy hydride ions was synthesized by reaction of atomic hydrogen
with potassium metal and potassium iodide.   Potassium iodo hydride was
identified by time of flight secondary ion mass spectroscopy, X-ray
photoelectron spectroscopy, proton and ^{39}K nuclear magnetic resonance
10   spectroscopy, Fourier transform infrared (FTIR) spectroscopy,
electrospray ionization time of flight mass spectroscopy, liquid
chromatography/mass spectroscopy, thermal decomposition with analysis
by gas chromatography, and mass spectroscopy, and elemental analysis.
Hydride ions with increased binding energies may form many novel
15   compounds with broad applications.

INTRODUCTION

Intense EUV emission was observed at low temperatures (e.g.
$<10^3 K$) from atomic hydrogen and certain atomized elements with one or
20   more unpaired electrons or certain gaseous ions which ionize at integer
multiples of the potential energy of atomic hydrogen [R. Mills, J. Dong, Y.
Lu, "Observation of Extreme Ultraviolet Hydrogen Emission from
Incandescently Heated Hydrogen Gas with Certain Catalysts", Science,
(1999) in progress].   Based on its exceptional emission, we used
25   potassium metal as a catalyst to release energy from atomic hydrogen.
Mills predicts an exothermic reaction whereby certain atoms or ions
serve as catalysts [R. Mills, *The Grand Unified Theory of Classical
Quantum Mechanics*, January 1999 Edition, BlackLight Power, Inc.,
Cranbury, New Jersey, Distributed by Amazon.com] to release energy
30   from hydrogen to produce an increased binding energy hydrogen atom
called a hydrino having a binding energy of

$$Binding\ Energy = \frac{13.6\ eV}{\left(\frac{1}{p}\right)^2}$$

(80)

where p is an integer greater than 1, designated as $H\left[\dfrac{a_H}{p}\right]$ where a_H is the radius of the hydrogen atom. Hydrinos are predicted to form by reacting an ordinary hydrogen atom with a catalyst having a net enthalpy of reaction of about

5
$$m \cdot 27.2 \, eV \tag{81}$$

where m is an integer [R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 1999 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com]. This catalysis releases energy from the hydrogen atom with a commensurate decrease
10 in size of the hydrogen atom, $r_n = n a_H$. For example, the catalysis of $H(n=1)$ to $H(n=1/2)$ releases $40.8 \, eV$, and the hydrogen radius decreases from a_H to $\dfrac{1}{2} a_H$.

A catalytic system is provided by the ionization of t electrons from an atom each to a continuum energy level such that the sum of the
15 ionization energies of the t electrons is approximately $m \times 27.2 \, eV$ where m is an integer. One such catalytic system involves potassium. The first, second, and third ionization energies of potassium are $4.34066 \, eV$, $31.63 \, eV$, $45.806 \, eV$, respectively [D. R. Linde, CRC Handbook of Chemistry and Physics, 78 th Edition, CRC Press, Boca Raton, Florida, (1997), p. 10-
20 214 to 10-216.

4. Microsc. Microanal. Microstruct., Vol. 3, 1, (1992)]. The triple ionization ($t=3$) reaction of K to K^{3+}, then, has a net enthalpy of reaction of $81.7426 \, eV$, which is equivalent to $m=3$ in Eq. (81).

$$81.7426 \, eV + K(m) + H\left[\frac{a_H}{p}\right] \to K^{3+} + 3e^- + H\left[\frac{a_H}{(p+3)}\right] + [(p+3)^2 - p^2] X 13.6 \, eV \tag{82}$$

25
$$K^{3+} + 3e^- \to K(m) + 81.7426 \, eV \tag{83}$$

And, the overall reaction is

$$H\left[\frac{a_H}{p}\right] \to H\left[\frac{a_H}{(p+3)}\right] + [(p+3)^2 - p^2] X 13.6 \, eV \tag{84}$$

Potassium ions can also provide a net enthalpy of a multiple of that of the potential energy of the hydrogen atom. The second ionization
30 energy of potassium is $31.63 \, eV$; and K^+ releases $4.34 \, eV$ when it is reduced to K. The combination of reactions K^+ to K^{2+} and K^+ to K, then,

106

has a net enthalpy of reaction of 27.28 eV, which is equivalent to $m = 1$ in Eq. (81).
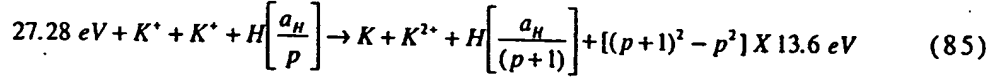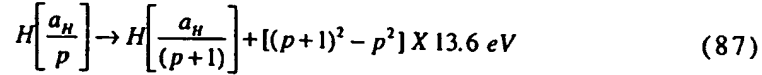
$$27.28\ eV + K^+ + K^+ + H\left[\frac{a_H}{p}\right] \rightarrow K + K^{2+} + H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2] \, X \, 13.6\ eV \tag{85}$$

$$K + K^{2+} \rightarrow K^+ + K^+ + 27.28\ eV \tag{86}$$

The overall reaction is

$$H\left[\frac{a_H}{p}\right] \rightarrow H\left[\frac{a_H}{(p+1)}\right] + [(p+1)^2 - p^2] \, X \, 13.6\ eV \tag{87}$$

A novel hydride ion having extraordinary chemical properties given by Mills [R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 1999 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com] is predicted to form by the reaction of an electron with a hydrino (Eq. (88)). The resulting hydride ion is referred to as a hydrino hydride ion, designated as $H^-(1/p)$.

$$H\left[\frac{a_H}{p}\right] + e^- \rightarrow H^-(1/p) \tag{88}$$

The hydrino hydride ion is distinguished from an ordinary hydride ion having a binding energy of 0.8 eV. The latter is hereafter referred to as "ordinary hydride ion". The hydrino hydride ion is predicted [R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 1999 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com] to comprise a hydrogen nucleus and two indistinguishable electrons at a binding energy according to the following formula:

$$Binding\ Energy = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1+\sqrt{s(s+1)}}{p}\right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3}\left(1 + \frac{2^2}{\left[\frac{1+\sqrt{s(s+1)}}{p}\right]^3}\right) \tag{89}$$

where p is an integer greater than one, $s = 1/2$, π is pi, $\hbar$ is Planck's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge. The ionic radius is

$$r_1 = \frac{a_0}{p}\left(1 + \sqrt{s(s+1)}\right);\ s = \frac{1}{2} \tag{90}$$

From Eq. (90), the radius of the hydrino hydride ion $H^-(1/p)$; p = integer is $\frac{1}{p}$ that of ordinary hydride ion, $H^-(1/1)$.

107

A novel inorganic hydride compound *KHI* which comprises high binding energy hydride ions was synthesized by reaction of atomic hydrogen with potassium metal and potassium iodide. Potassium iodo hydride was identified by time of flight secondary ion mass spectroscopy
5   (ToF-SIMS), X-ray photoelectron spectroscopy (XPS), proton and ^{39}K nuclear magnetic resonance spectroscopy (NMR), Fourier transform infrared (FTIR) spectroscopy, electrospray ionization time of flight mass spectroscopy (ESITOFMS), liquid chromatography/mass spectroscopy (LC/MS), thermal decomposition with analysis by gas chromatography
10 (GC), and mass spectroscopy (MS), and elemental analysis.

Alkali and alkaline earth hydrides react violently with water to release hydrogen gas which subsequently ignites due to the exothermic reaction with water. Typically metal hydrides decompose upon heating at a temperature well below the melting point of the parent metal. These
15 saline hydrides, so called because of their saltlike or ionic character, are the monohydrides of the alkali metals and the dihydrides of the alkaline-earth metals. Mills predicts a hydrogen-type molecule having a first binding energy of about

$$Binding\ Energy = \frac{15.5}{\left(\frac{1}{p}\right)^2}\ eV \tag{91}$$

20 Dihydrino molecules may be produced by the thermal decomposition of hydrino hydride ions. $H^-(1/2)$ may be less reactive and more thermally stable than ordinary potassium hydride, but may react to form a hydrogen-type molecule. Potassium iodo hydride $KH(1/2)I$ may be heated to release dihydrino by thermal decomposition.

25
$$2KH(1/2)I \xrightarrow{\Delta} H_2^*\left[2c' = \frac{a_o}{\sqrt{2}}\right] + 2KI \tag{92}$$
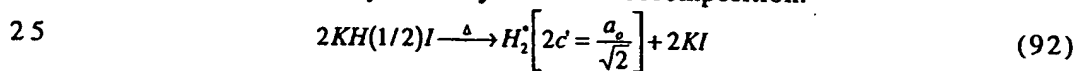
where $2c'$ is the internuclear distance and a_o is the Bohr radius [R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 1999 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com]. The possibility of releasing dihydrino by thermally
30 decomposing potassium iodo hydride with identification by gas chromatography was explored.

The first ionization energy, IP_1, of the dihydrino molecule

$$H_2^*\left[2c' = \frac{\sqrt{2}a_o}{2}\right] \rightarrow H_2^*[2c' = a_o]^+ + e^- \tag{93}$$
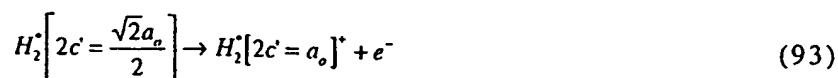
is $IP_i = 62\,eV$ ($p = 2$ in Eq. (91)); whereas, the first ionization energy of ordinary molecular hydrogen, $H_2[2c' = \sqrt{2}a_o]$, is $15.46\,eV$. Thus, the possibility of using mass spectroscopy to discriminate $H_2[2c' = \sqrt{2}a_o]$ from

$H_2^*\left[2c' = \frac{a_o}{\sqrt{2}}\right]$ on the basis of the large difference between the ionization

energies of the two species was explored. A novel high binding energy

hydrogen molecule assigned to dihydrino $H_2^*\left[2c' = \frac{a_o}{\sqrt{2}}\right]$ was identified by

the thermal decomposition of KHI with analysis by gas chromatography, and mass spectroscopy.

The discovery of novel hydride ions with high binding energies has implications for a new field of hydride chemistry. These novel compositions of matter and associated technologies may have far-reaching applications in many industries including chemical, electronics, computer, military, energy, and aerospace in the form of products such as batteries, propellants, solid fuels, munitions, surface coatings, structural materials, and chemical processes.

EXPERIMENTAL

Synthesis

Potassium iodo hydride was prepared in a stainless steel gas cell shown in FIGURE 104 comprising a Ti screen hydrogen dissociator (Belleville Wire Cloth Co., Inc.), potassium metal catalyst (Aldrich Chemical Company), and KI (Aldrich Chemical Company 99.9 %) as the reactant. The 304-stainless steel cell 301 was in the form of a tube having an internal cavity 317 of 359 millimeters in length and 73 millimeters in diameter. The top end of the cell was welded to a high vacuum 4 5/8 inch bored through conflat flange 318. The mating blank conflat flange 319 contained a single coaxial hole in which was welded a 3/8 inch diameter stainless steel tube 302 that was 100 cm in length and contained an inner coaxial tube of 1/8 inch diameter. A silver plated copper gasket was placed between the two flanges. The two flanges are held together with 10 circumferential bolts. The bottom of the 3/8 inch

tube 302 was flush with the bottom surface of the top flange 319. The outer tube 302 served as a vacuum line from the cell and the inner tube served as a hydrogen or helium supply line to the cell. The cell 301 was surrounded by four heaters 303, 304, 305, and 306. Concentric to the
5 heaters was high temperature insulation (AL 30 Zircar) 307. Each of the four heaters were individually thermostatically controlled.

The cylindrical wall of the cell 301 was lined with two layers of Ti screen 308 totaling 150 grams. 75 grams of crystalline *KI* 309 was poured into the cell 301. About 0.5 grams of potassium metal was added
10 to the cell under an argon atmosphere. The cell 301 was then continuously evacuated with a high vacuum turbo pump 310 to reach 50 millitorr measured by a pressure gauge (Varian Convector, Pirrani type) 312. The cell was heated by supplying power to the heaters 303, 304, 305, and 306. The heater power of the largest heater 305 was measured
15 using a wattmeter (Clarke -Hess model 259). The temperature of the cell was measured with a type K thermocouple (Omega). The cell temperature was then slowly increased over 2 hours to 300 °C using the heaters that were controlled by a type 97000 controller. The power to the largest heater 305 and the cell temperature and pressure were
20 continuously recorded by a DAS. The vacuum pump valve 311 was closed. Hydrogen was supplied from tank 316 through regulator 315 to the valve 314. Hydrogen was slowly added to maintain a pressure within the range of 1000 torr to 1500 torr by opening valve 313. The temperature of the cell was then slowly increased to 650 °C over 5 hours.
25 The hydrogen valve 313 was closed except to maintain the pressure at 1500 torr. After 24 hours, the temperature of the cell 301 was reduced to 400 °C at a rate of 15 °C/hr. The hydrogen tank 316 was replaced by a helium tank. Helium which was flowed through the inner supply line 302 to the cell while a vacuum was pulled on the outer vacuum line 302
30 to remove volatilized potassium metal at 400 °C. The cell was then cooled and opened. About 75 grams of blue crystals were observed to have formed in the bottom of the cell.

ToF-SIMS Characterization
35   The crystalline samples were sprinkled onto the surface of a double-sided adhesive tape and characterized using a Physical Electronics

TFS-2000 ToF-SIMS instrument. The primary ion gun utilized a $^{69}Ga^+$
liquid metal source. In order to remove surface contaminants and expose
a fresh surface, the samples were sputter cleaned for 30 seconds using a
$40\mu m$ X $40\mu m$ raster. The aperture setting was 3, and the ion current

5   was 600 pA resulting in a total ion dose of 10^{15} $ions/cm^2$.

During acquisition, the ion gun was operated using a bunched (pulse
width 4 ns bunched to 1 ns) 15 kV beam [Microsc. Microanal.
Microstruct., Vol. 3, 1, (1992); For recent specifications see PHI Trift II,
ToF-SIMS Technical Brochure, Eden Prairie, MN 55344]. The total ion

10   dose was 10^{12} $ions/cm^2$. Charge neutralization was active, and the post
accelerating voltage was 8000 V. Three different regions on each sample
of $(12\mu m)^2$, $(18\mu m)^2$, and $(25\mu m)^2$.were analyzed. The positive and negative
SIMS spectra were acquired. Representative post sputtering data is
reported.

15

XPS Characterization

A series of XPS analyses were made on the crystalline samples
using a Scienta 300 XPS Spectrometer. The fixed analyzer transmission
mode and the sweep acquisition mode were used. The step energy in the

20   survey scan was $0.5 eV$, and the step energy in the high resolution scan
was $0.15 eV$. In the survey scan, the time per step was 0.4 seconds, and
the number of sweeps was 4. In the high resolution scan, the time per
step was 0.3 seconds, and the number of sweeps was 30. $C ls$ at $284.5 eV$
was used as the internal standard.

25

NMR Spectroscopy

^1H MAS NMR was performed on the blue crystals. The data were
recorded on a Bruker DSX-400 spectrometer at 400.13 MHz. Samples
were packed in zirconia rotors and sealed with airtight O-ring caps under

30   an inert atmosphere. The MAS frequency was 4.5 kHz. During data
acquisition, the sweep width was 60.06 kHz; the dwell time was $8.325 \mu sec$,
and the acquisition time was 0.03415 sec/scan. The number of scans was
typically 32 or 64. Chemical shifts were referenced to external
tetramethylsilane (TMS). The reference comprised KH (Aldrich Chemical

35   Company 99%).

111

^{39}K MAS NMR was performed on the blue crystals. The data were recorded on a Bruker DSX-400 spectrometer at 18.67 MHz. Samples were packed in zirconia rotors and sealed with airtight O-ring caps under an inert atmosphere. The MAS frequency was 4.5 kHz. During data

5   acquisition, the sweep width was 125 kHz; the dwell time was 4.0 μsec, and the acquisition time was 0.01643 sec/scan. The number of scans was 96. Chemical shifts were referenced to external *KBr* (Aldrich Chemical Company 99.99%). References comprised *KI* (Aldrich Chemical Company 99.99%) and *KH* (Aldrich Chemical Company 99%).

10

FTIR Spectroscopy

Samples were transferred to an infrared transmitting substrate and analyzed by FTIR spectroscopy using a Nicolet Magna 550 FTIR Spectrometer with a NicPlan FTIR microscope. The number of scans was

15   250 for both the sample and background. The resolution was 8.000 cm^{-1}. A dry air purge was applied.

Electrospray-Ionization-Time-Of-Flight-Mass-Spectroscopy (ESITOFMS)

The data was obtained on a Mariner ESI TOF system fitted with a

20   standard electrospray interface. The samples were submitted via a syringe injection system (250 μl) with a flow rate of 5.0 μl/min. The solvent was water/ethanol (1:1). A reference comprised *KI* (Aldrich Chemical Company 99.99%).

25   Liquid-Chromatography/Mass-Spectroscopy (LC/MS)

Reverse phase partition chromatography was performed with a PE Sciex API 365 LC/MS/MS System. The column was a LC C18 column, 5.0 μm, 150 X 2 mm (Columbus 100 Å Serial #207679). 31.1 mg of blue crystals were dissolved in 6.2 ml solvent of 90% HPLC water and 10%

30   HPLC methanol to give a concentration of 5 mg/ml. The sample was eluted using a gradient technique with the eluents of a solution A (water + 5 mM ammonium acetate + 1% formic acid) and a solution B (acetonitrile/water (90/10) + 5 mM ammonium acetate + 0.1% formic acid). The gradient profile was:

35

112

Time (min.):	0	3	18	27	28	30
%A	100	100	0	0	100	Stop
%B	0	0	100	100	0	Stop

The flow rate was 1 ml/min. The injection volume was 1 μl. The pump pressure was 110 PSI.

A turbo electrospray ionization (ESI) and triple-quadrapole mass spectrometer was used. The turbo ESI converts the mobile phase to a fine mist of ions. These ions are then separated according to mass in a quadrapole radio frequency electric field. LC/MS provides information comprising 1.) the solute polarity based on the retention time, 2.) quantitative information comprising the concentration based on the chromatogram peak area, and 3.) compound identification based on the mass spectrum or mass to charge ratio of a peak. The mass spectroscopy mode was positive. The selected ion mass to charge ratios (SIM) were m/e = 39.0, 204.8, 370.6, 536.8, and 702.6. The dwell time was 400 ms, and the pause was 2 ms. The turbo gas was 8 L/min. (25 PSI).

The controls comprised *KI* (Aldrich Chemical Company 99.99%) and sample solvent alone.

Elemental Analysis

Elemental analysis was performed by Galbraith Laboratories, Inc., Knoxville, TN. Potassium was determined by Inductively Coupled Plasma using an ICP Optima 3000. Iodide was determined volumetrically by iodometric titration with thiosulfate. The hydrogen was determined by a Perkin-Elmer Elemental Analyzer (#240) using ASTM D-5291 method wherein the sample was combusted in a tube furnace at 950 °C and the water was measured by a thermal conductivity detector. The sample was handled in an inert atmosphere.

Thermal Decomposition with Analysis by Gas Chromatography

The gas cell sample comprised deep blue crystals that changed to white crystals upon exposure to air over about a two week period. 0.5 grams of the sample was placed in a thermal decomposition reactor under an argon atmosphere. The reactor comprised a 1/4" OD by 3" long quartz tube that was sealed at one end and connected at the open end

113

with Swagelock™ fittings to a T. One end of the T was connected to a
needle valve and a Welch Duo Seal model 1402 mechanical vacuum
pump. The other end was attached to a septum port. The apparatus was
evacuated to between 25 and 50 millitorr. The needle valve was closed
5   to form a gas tight reactor. The sample was heated in the evacuated
quartz chamber containing the sample with an external Nichrome wire
heater using a Variac transformer. The sample was heated to above 600
°C by varying the transformer voltage supplied to the Nichrome heater
until the sample melted and the blue color disappeared. Gas released
10 from the sample was collected with a $500 \mu l$ gas tight syringe through the
septum port and immediately injected into the gas chromatograph. The
reactor was cooled to room temperature, and a mixture of white and
orange crystalline solid remained.

Gas samples were analyzed with a Hewlett Packard 5890 Series II
15 gas chromatograph equipped with a thermal conductivity detector and a
60 meter, 0.32 mm ID fused silica Rt-Alumina capillary PLOT column
(Restek, Bellefonte, PA). The column was conditioned at 200° C for 18-72
hours before each series of runs. Samples were run at -196° C using Ne
as the carrier gas. The 60 meter column was run with the carrier gas at
20 3.4 psi with the following flow rates: carrier - 2.0 ml/min, auxiliary - 3.4
ml/min, and reference - 3.5 ml/min, for a total flow rate of 8.9 ml/min.
The split rate was 10.0 ml/min.

The control hydrogen gas was ultrahigh purity (MG Industries).
Control *KI* (Aldrich Chemical Company ACS grade, 99+%,) was also treated
25 by the same method as the blue crystals.

Thermal Decomposition with Analysis by Mass Spectroscopy

Mass spectroscopy was performed on the gases released from the
thermal decomposition of the blue crystals. One end of a 4 mm ID fritted
30 capillary tube containing about 5 mg of sample was sealed with a 0.25 in.
Swagelock union and plug (Swagelock Co., Solon, OH). The other end was
connected directly to the sampling port of a Dycor System 1000
Quadrapole Mass Spectrometer (Model D200MP, Ametek, Inc., Pittsburgh,
PA with a HOVAC Dri-2 Turbo 60 Vacuum System). The capillary was
35 heated with a Nichrome wire heater wrapped around the capillary. The
mass spectrum was obtained at the ionization energy of 70 eV and 30 eV

at different sample temperatures in the region $m/e = 0-50$. With the detection of hydrogen indicated by a $m/e = 2$ peak, the intensity as a function of time for masses $m/e = 1$, $m/e = 2$, $m/e = 4$ and $m/e = 5$ was obtained while changing the ionization potential (IP) of the mass

5   spectrometer from 30 eV to 70 eV.

The control hydrogen gas was ultrahigh purity (MG Industries).

RESULTS AND DISCUSSION

ToF-SIMS

10   The positive ToF-SIMS spectrum obtained from the blue crystals is shown in FIGURE 105. The positive ion spectrum of the blue crystals and that of the KI control are dominated by the K^+ ion. The comparison of the positive ToF-SIMS spectrum of the KI control with the blue crystals demonstrates that the $^{39}K^+$ peak of the blue crystals may saturate the

15   detector and give rise to a peak that is atypical of the natural abundance of ^{41}K. The natural abundance of ^{41}K is 6.7%; whereas, the observed ^{41}K abundance from the blue crystals is 73%. The high resolution mass assignment of the $m/z = 41$ peak of the blue crystals was consistent with ^{41}K, and no peak was observed at $m/z = 42.98$ ruling out $^{41}KH_2^+$. Moreover,

20   the natural abundance of ^{41}K was observed in the positive ToF-SIMS spectra of $KHCO_3$, KNO_3, and KI standards that were obtained with an ion current such that the ^{39}K peak intensity was an order of magnitude higher than that given for the blue crystals. The saturation of the ^{39}K peak of the positive ToF-SIMS spectrum by the blue crystals is indicative

25   of a unique crystalline matrix [*Practical Surface Analysis*, 2nd Edition, Volume 2, Ion and Neutral Spectroscopy, D. Briggs, M. P. Seah (Editors), Wiley & Sons, New York, (1992)].

A K^{2+} ion was only observed in the positive ion spectrum of the blue crystals. Ga^+ $m/z = 69$, K_2^+ $m/z = 78$, $K(KCl)^+$ $m/z = (113)$, I^+ $m/z = 127$,

30   KI^+ $m/z = 166$, and a series of positive ions $K[KI]_n^+$ $m/z = (39 + 166n)$ are also observed.

The negative ion ToF-SIMS of the blue crystals shown in FIGURE 106 was dominated by H^- and I^- peaks of about equal intensity. Iodide alone dominated the negative ion ToF-SIMS of the KI control. For both,

35   O^- $m/z = 16$, OH^- $m/z = 17$, Cl^- $m/z = 35$, KI^- $m/z = 166$, a series of negative ions $I[KI]_n$ $m/z = (127 + 166n)$ are also observed.

115

XPS

A survey spectrum was obtained over the region $E_b = 0\ eV$ to $1200\ eV$.
The primary element peaks allowed for the determination of all of the
5   elements present in the blue crystals and the control KI. The survey
spectrum also detected shifts in the binding energies of the elements
which had implications to the identity of the compound containing the
elements.

The XPS survey scan of the blue crystals is shown in FIGURE. 107.
10   $C 1s$ at $284.5\ eV$ was used as the internal standard for the blue crystals
and the control KI. The major species present in the blue crystals and
the control are potassium and iodide. Trace small amounts of carbonate
carbon and oxygen were also identified in the blue crystals. The $K 3p$
and $K 3s$ peaks of the blue crystals were shifted relative to those of the
15   control KI. The $K 3p$ and $K 3s$ of the blue crystals occurred at 17 eV and
33 eV, respectively. The $K 3p$ and $K 3s$ of the control KI occurred at 17.5
eV and 33.5 eV, respectively. Hydrogen is the only element which does
not have primary element peaks; thus, it is the only candidate to produce
the shifted peaks.

20   No elements were present in the survey scan which could be
assigned to peaks in the low binding energy region with the exception of
the $K 3p$ and $K 3s$ peaks at 17 eV and 33 eV, respectively, the $O 2s$ at 23
eV, and the $I 5s$, $I 4d_{5/2}$, and $I 4d_{3/2}$ peaks at 12.7 eV, 51 eV, and 53 eV,
respectively. Accordingly, any other peaks in this region must be due to
25   novel species. The 0-100 eV binding energy region of a high resolution
XPS spectrum of the blue crystals is shown in FIGURE 108. The 0-100 eV
binding energy region of a high resolution XPS spectrum of the control KI
is shown in FIGURE 109. The XPS spectrum of the blue crystals differs
from that of KI by having additional features at 9.1 eV and 11.1 eV. The
30   XPS peaks centered at 9.0 eV and 11.1 eV that do not correspond to any
other primary element peaks may correspond to the
$H^-(n = 1/4)\ E_b = 11.2\ eV$ hydride ion predicted by Mills [R. Mills, *The Grand
Unified Theory of Classical Quantum Mechanics*, January 1999 Edition,
BlackLight Power, Inc., Cranbury, New Jersey, Distributed by
35   Amazon.com] (Eq. (89)) in two different chemical environments where E_b
is the predicted vacuum binding energy. In this case, the reaction to

116

form $H^-(n=1/4)$ is given by Eqs. (82-84) and Eq. (88). The hydride ion $H^-(n=1/2)\,E_b = 3.05\,eV$ may also be present in the XPS of the blue crystals under the valance peak at about 3.5 eV. The reaction to form $H^-(n=1/2)$ is given by Eqs. (85-87) and Eq. (88). Studies to remove iodide followed
5   by XPS are in progress.

NMR

The ^1H MAS NMR spectra of the control KH and the blue crystals relative to external tetramethylsilane (TMS) are shown in FIGURE 110
10   and FIGURE 111, respectively. Three distinguishable resonances at 3.65, 0.13 and -0.26 ppm, respectively, were found in the NMR of KH. The broad 3.65 ppm peak of KH is assigned to KOH formed from air exposure during sample handling. The peaks at 0.13 and -0.26 ppm are assigned to hydride H in different chemical environments.
15   Three distinguishable resonances at 0.081, -0.376 and -1.209 ppm, respectively, were found in the NMR of the blue crystals. A fourth very broad resonance may be present at -2.5 ppm. The peaks at 0.081 and -0.376 ppm are within the range of KH and may be ordinary hydride H in two different chemical environments that are distinct from those of
20   the control KH. The resonances at -1.209 ppm and possibly at -2.5 ppm may be due to novel hydride ions.

The color of the blue crystals was found to change to white over 2 weeks of exposure to air. The color-fade rate was greatly increased upon grinding the blue crystal into a fine powder. A dynamic ^1H NMR study
25   following the possible oxidation or hydrolysis of the blue crystals when exposed to air is shown in FIGURES 112-115. The ^1H MAS NMR spectra from ground blue crystals relative to external tetramethylsilane (TMS) following air exposure times of 1 minute, 20 minutes, 40 minutes, and 60 minutes are shown in FIGURES 112-115. Downfield ^1H resonances shifted
30   gradually to 3.861 and 4.444 ppm and then to 5.789. Upfield resonances shifted to 1.157 ppm, as the exposure to air was prolonged and the blue color concomitantly faded to white. The peak at 5.789 may be do to H of KOH in a chemical environment that is different from that of KOH formed by air exposure of KH. Since the downfield shift of the peak at
35   5.789 is substantially different from that observed for the control KH, 3.65 ppm, it may be due to KOH or a compound comprising KOH wherein

117

H is increased binding energy hydrogen. The resonance at 1.157 comprises at least two peaks, one of which has a very broad upfield feature. These peaks may be novel hydride ions which are stable in air. In this case the chemical environment is different from that of the blue

5   crystals which showed potential novel hydride peaks at -1.209 ppm and possibly at -2.5 ppm. These observations strongly suggest that the H species in the blue crystals are new hydride species and may be responsible for the blue color. Decoupling studies are in progress to resolve the broad features of the blue crystal spectrum.

10   The ^{39}K MAS NMR spectra of KH, KI, and the blue crystals each showed a single resonance at 64.56, 52.71, and 53.32 ppm respectively. It is clear that the K local structure in the blue crystals resembles that in KI.

15   FTIR

The FTIR spectra of KI (99.99%) was compared with that of the blue crystals. The FTIR spectra ($45-3800\,cm^{-1}$) of KI is given by Nyquist and Kagel [R. A. Nyquist and R. O. Kagel, *Infrared Spectra of Inorganic Compounds*, Academic Press, New York, (1971), pp. 464-465]. The FTIR

20   spectra ($500-4000\,cm^{-1}$) of the blue crystals is shown in FIGURE 116. There are no vibrational bands in the $800-4000\,cm^{-1}$ region that can usually be assigned to covalent bondings. This eliminates the possibility of HI molecule embedded in KI crystals, since the H-I stretching mode is not observed at $\sim 2309\,cm^{-1}$. The FTIR spectra ($500-1500\,cm^{-1}$) of the blue

25   crystals is shown in FIGURE 117. Several bands shown in FIGURE 117 such as 682, 712, 730 cm^{-1} are found in the region assignable to ionic bonding or deformation vibration. The K-H vibrational band may be expected in this region. These bands are not present in pure KI. This implies that the compound of the blue crystals is ionic-like and contains

30   different species from KI.

ESITOFMS

The positive ion ESITOFMS spectrum of the blue crystals and that of the KI control are dominated by the K^+ ion. A series of positive ions

35   $K[KI]_n^+$ $m/z = (39+166n)$ were also observed. In addition, KHI^+ was only observed from the blue crystals.

118

LC/MS

No chromatographic .peaks were observed of the Selected Ion Monitoring LC/MS analysis of KI control and sample solvent alone
5   control.

FIGURE 118 is the results of the Selected Ion Monitoring LC/MS analysis of the blue crystals wherein the mass spectrum comprised the $m/z = 204.6$ ion signal. A chromatographic peak was observed at $RT = 22.45$ min. which corresponds to a nonpolar compound which gives
10   rise to a $K(KI)^+$ mass fragment. The LC peak shown in FIGURE 118 at $RT = 2.21$ min. that comes out with the solvent front after injection corresponds to KI that gives rise to mass fragments K^+ and $K(KI)_x^+$.

FIGURE 119 is the results of the Selected Ion Monitoring LC/MS analysis of the blue crystals wherein the mass spectrum comprised the
15      $m/z = 307.6$ ion signal. Chromatographic peaks were observed at $RT = 11.42$ min. and $RT = 23.38$ min. which correspond to a nonpolar compounds having the $K(KI)_2^+$ mass spectrum fragment. The LC peak shown in FIGURE 119 at $RT = 2.21$ min. that comes out with the solvent front after injection corresponds to KI that gives rise to mass fragments
20   K^+ and $K(KI)_x^+$.

The LC/MS data indicated that the blue crystal comprises a novel compound KHI which may contain two different hydride ions which gives rise to different mass fragmentation patterns. One KHI compound with a retention time of $RT = 11.42$ min. may give rise to a $K(KI)_2^+$ mass fragment.
25   Whereas, a second KHI compound with a retention of about $RT = 23$ min. may give rise to a $K(KI)^+$ and a $K(KI)_2^+$ mass fragment.

Gas Chromatography

The gas chromatograph of the normal hydrogen gave the retention
30   time for para hydrogen and ortho hydrogen as 22 minutes and 24 minutes, respectively. Control KI and KI exposed to 500 mtorr of hydrogen at 600 °C in the stainless steel reactor for 48 hours showed no hydrogen release upon heating to above 600 °C with complete melting of the crystals. Dihydrino or hydrogen was released when the blue crystals
35   were heated to above 600 °C with melting which coincided with the loss of the dark blue color of these crystals. The gas chromatograph of the

119

dihydrino or hydrogen released from the blue crystals when the sample was heated to above 600 °C with melting is shown in FIGURE 120. In previous studies [R. Mills, "NOVEL HYDRIDE COMPOUNDS", PCT US98/14029 filed on July 7, 1998], it was found that hydrogen must be present with dihydrino $H_2^*\left[n=\frac{1}{2};\; 2c'=\frac{\sqrt{2}a_0}{2}\right]$ to identify the latter since the migration times are close. But, these results confirm that the blue crystals are a hydride.

Mass Spectroscopy

The dihydrino was identified by mass spectroscopy as a species with a mass to charge ratio of two ($m/e=2$) that has a higher ionization potential than that of normal hydrogen by recording the ion current as a function of the electron gun energy. The intensity as a function of time for masses $m/e=1$, $m/e=2$, and $m/e=3$ obtained while changing the ionization potential (IP) of the mass spectrometer from 30 eV to 70 eV is shown for gas released from thermal decomposition of the blue crystals and ultrapure hydrogen in FIGURE 121 and FIGURE 122, respectively. Upon increasing the ionization potential from 30 eV to 70 eV, typically the $m/e=2$ ion current for the blue crystal sample increased by a factor of about 1000. Under the same pressure conditions, the $m/e=2$ ion current for the ultrapure hydrogen increased by a factor of less than 2.

The mass spectra ($m/e=0-50$) of the gases released from the thermal decomposition of the blue crystals at an ionization potential of 30 eV and 70 eV were recorded. As the ionization energy was increased from 30 eV to 70 eV a $m/e=4$ and a $m/e=5$ peak were observed that was assigned to $H_4^*(1/2)$ and $H_5^*(1/2)$., respectively. No helium was observed by gas chromatography as given above in gas chromatography section. The peaks serve as a signatures for the presence of dihydrino molecules.

Elemental Analysis

The quantitative elemental analysis shows that the blue crystal consists of 0.5 wt% H, 22.58 wt% K and 75.40 wt% I, or in equivalent $KI_{1.028}H_{0.865}$.
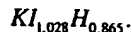
DISCUSSION

The elemental analysis and the positive and negative ToF-SIMS
results of the blue crystals are consistent with the proposed structure
KHI. The NMR data and the XPS data indicate that two form forms of

5   hydride were observed. The compounds *KI* and *KH* are known wherein
the potassium ion is in a +1 state. The structure *KHI* is unknown and
extraordinary. The implied valance of potassium is 2+. A K^{2+} peak was
observed in the positive ToF-SIMS which supports 2+ as the valance
state. High resolution solids probe magnetic sector mass spectroscopy is

10 in progress to confirm this state. The preliminary results are positive.

Another unusual feature of the blue crystals is its intense dark blue
color. Potassium metal my be embedded in *KI* crystals, in which
potassium metal ionizes into K^+ and a free electron. This capped free
electron may give rise to blue color of the crystals. Therefore, a liquid

15 ammonia solvation experiment was designed to test if there is any *K*
metal entrapped in the crystals. Alkali metals are readily soluble in
liquid ammonia to give bright blue solutions. In such solutions, the alkali
metal ionizes to give a cation M^+ and a quasi-free electron. The free
electron is distributed over a cavity in the solvent of radius 300-340 pm

20 formed by displacement of 2-3 NH_3 molecules. This species has a broad
absorption band extending into the infrared with a maximum of ~1500 *nm*.
It is the short wavelength tail of this band which gives rise to the deep-
blue color of the solution.

The blue crystals were dissolved in liquid ammonia. However, the

25 solvation of the blue crystals in liquid ammonia did not produce a blue
colored solution. Instead, the blue crystals dissolved with the solution
remaining clear. White crystals were recovered after the evaporation of
the ammonia. This experiment eliminates the possibility of *K* metal as
color center in the blue crystals.

30 Potassium metal reacts slowly with ethanol to release hydrogen gas.
The blue crystals were dissolved in anhydrous ethanol. No gas evolved,
and the solution remained clear. This result indicates that the blue color
of the crystals may not be due to an impurity, e.g., color center, such as *K*
metal in *KI* crystal, since no hydrogen gas was produced. This

35 experiment also eliminates the possibility of *K* metal as color center in
the blue crystals.

121

The blue crystals appear to be an integrated, single compound wherein large amounts of uniform crystals can be prepared. The blue color may be due to the 407 nm continuum of $H^-(1/2)$ as given by Eq. (89). The thermal decomposition with a release of a hydrogen-type molecule resulted in the loss of the blue color. Thus, the blue color is dependent on the presence of the H of KHI. The presence of some $H^-(1/2)$ is indicated by the thermal decomposition with the identification of a hydrogen-type molecule assigned to $H_2^*\left[2c' = \frac{a_o}{\sqrt{2}}\right]$ with an ionization potential of $62\,eV$ (Eq. (92)). Emission spectroscopy with excitation by a plasma source is in progress to determine the presence of $H^-(1/2)$ emission.

When the blue crystals were pulverized or exposed to air for a prolong period of the order of two weeks the blue faded and white crystals remained. Investigations of the air reaction products are in progress preliminary data indicates that the product is a hydride containing carbon dioxide, oxygen, and water derived species. For example, the positive ToF-SIMS of the air exposed crystals contained three new series of positive ions: $\{ K[KH\,KHCO_3]_n^+ \quad m/z = (39+140n),$ $K_2OH[KH\,KHCO_3]_n^+ \quad m/z = (95+140n),$ and $K_3O[KH\,KHCO_3]_n^+ \quad m/z = (133+140n)\}$. These ions correspond to inorganic clusters containing novel hydride combinations (i.e. $KH\,KHCO_3$ units plus other positive fragments). The negative ion spectrum was dominated by O^- and OH^- peaks as well as H^- and I^- peaks. A $KHIO^-$ peak was present only in the negative spectrum of the air exposed blue crystals and not in the spectrum of air exposed KI control.

CONCLUSION

The ToF-SIMS, XPS, NMR, FTIR, ESITOFMS, LC/MS, thermal decomposition with analysis by GC, and MS, and elemental analysis results confirm the identification of KHI having hydride ions. Two forms of hydride ion may be formed according to Eqs. (84), (87), and (88) which is supported by the XPS, NMR, and LC/MS data. The thermal decomposition with mass spectroscopic analysis indicates that at least $H^-(1/2)$ is present in KHI which may be responsible for the blue color. The chemical structure and properties of this compound having a hydride

122

ion with a high binding energy are indicative of a new field of hydride chemistry. The novel hydride ion may combine with other cations such as other alkali cations and alkaline earth, rare earth, and transition element cations. Numerous novel compounds may be synthesized with
5 extraordinary properties relative to the corresponding compounds having ordinary hydride ions. These novel compounds may have a breath of applications.

CLAIMS

1.   A compound comprising
       (a) at least one neutral, positive, or negative increased binding
5   energy hydrogen species having a binding energy
              (i) greater than the binding energy of the corresponding
       ordinary hydrogen species, or
              (ii) greater than the binding energy of any hydrogen species
       for which the corresponding ordinary hydrogen species is unstable or is
10   not observed because the ordinary hydrogen species' binding energy is
       less than thermal energies at ambient conditions, or is negative; and
       (b) at least one other element.

2.   A compound of claim 1 or 2 characterized in that the increased
15   binding energy hydrogen species is selected from the group consisting of
       H_n, H_n^-, and H_n^+ where n is a positive integer, with the proviso that n is
       greater than 1 when H has a positive charge.

3.   A compound of claim 1 characterized in that the increased binding
20   energy hydrogen species is selected from the group consisting of (a)
       hydride ion having a binding energy that is greater than the binding of
       ordinary hydride ion (about 0.8 eV) for $p = 2$ up to 23 in which the
       binding energy is represented by

$$Binding\ Energy = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1+\sqrt{s(s+1)}}{p}\right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3}\left(1 + \frac{2^2}{\left[\frac{1+\sqrt{s(s+1)}}{p}\right]^3}\right)$$

25   where p is an integer greater than one, $s = 1/2$, π is pi, $\hbar$ is Planck's
       constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the
       electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is
       the elementary charge; (b) hydrogen atom having a binding energy
       greater than about 13.6 eV; (c) hydrogen molecule having a first binding
30   energy greater than about 15.5 eV; and (d) molecular hydrogen ion
       having a binding energy greater than about 16.4 eV.

124

4.   A compound of claim 3 characterized in that the increased binding energy hydrogen species is a hydride ion having a binding energy of about 3.0, 6.6, 11.2, 16.7, 22.8, 29.3, 36.1, 42.8, 49.4, 55.5, 61.0, 65.6, 69.2, 71.5, 72.4, 71.5, 68.8, 64.0, 56.8, 47.1, 34.6, 19.2, or 0.65 eV.

5.   A compound of claim 4 characterized in that the increased binding energy hydrogen species is a hydride ion having the binding energy:

$$Binding\ Energy = \frac{\hbar^2\sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1+\sqrt{s(s+1)}}{p}\right]^2} - \frac{\pi\mu_0 e^2\hbar^2}{m_e^2 a_0^3}\left(1 + \frac{2^2}{\left[\frac{1+\sqrt{s(s+1)}}{p}\right]^3}\right)$$

where p is an integer greater than one, $s = 1/2$, π is pi, $\hbar$ is Planck's constant bar, μ_o is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_o is the Bohr radius, and e is the elementary charge.

6.   A compound of claim 1 characterized in that the increased binding energy hydrogen species is selected from the group consisting of

(a) a hydrogen atom having a binding energy of about $\dfrac{13.6\ eV}{\left(\dfrac{1}{p}\right)^2}$

where p is an integer,

(b) an increased binding energy hydride ion (H^-) having a binding

energy of about $\dfrac{\hbar^2\sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1+\sqrt{s(s+1)}}{p}\right]^2} - \dfrac{\pi\mu_0 e^2\hbar^2}{m_e^2 a_0^3}\left(1 + \dfrac{2^2}{\left[\frac{1+\sqrt{s(s+1)}}{p}\right]^3}\right)$ where

$s = 1/2$, π is pi, $\hbar$ is Planck's constant bar, μ_o is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_o is the Bohr radius, and e is the elementary charge;

(c) an increased binding energy hydrogen species $H_4^+(1/p)$;

(d) an increased binding energy hydrogen species trihydrino molecular ion, $H_3^+(1/p)$, having a binding energy of about $\dfrac{22.6}{\left(\dfrac{1}{p}\right)^2}\ eV$ where p

is an integer,

125

(e) an increased binding energy hydrogen molecule having a binding energy of about $\dfrac{15.5}{\left(\dfrac{1}{p}\right)^2} eV$; and

(f) an increased binding energy hydrogen molecular ion with a binding energy of about $\dfrac{16.4}{\left(\dfrac{1}{p}\right)^2} eV$.

5

7.   A compound of claim 6 characterized in that p is from 2 to 200.

8.   A compound of claim 1 which is greater than 50 atomic percent pure.

10

9.   A compound of claim 8 which is greater than 90 atomic percent pure.

10.   A compound of claim 9 which is greater than 98 atomic percent

15   pure.   •

11.   A compound of claim 1 characterized in that said increased binding energy hydrogen species is negative.

20   12.   A compound of claim 11 comprising at least one cation.

13.   A compound of claim 12 characterized in that the cation is a proton, H_2^+, H_3^+, $H_2^+\left[2c' = \dfrac{2a_o}{p}\right]^+$, $H_3^+(1/p)$, or $H_4^+(1/p)$.

25   14.   A compound of claim 1 characterized in that the other element is an ordinary hydrogen atom or an ordinary hydrogen molecule.

15.   A compound of claim 1 having a formula $\left[KH_mKCO_3\right]_n$ characterized in that m and n are each an integer, the compound contains at least one

30   H, and the hydrogen content H_m of the compound comprises at least one said increased binding energy hydrogen species.

16. A compound of claim 1 having a formula $[KH_mKNO_3]_n^{m^{\cdot+}}$ $n'\,X^-$ characterized in that m, m'; n and n' are each an integer, X is a singly negative charged anion, the compound contains at least one H, and the hydrogen content H_{ai} of the compound comprises at least one said increased binding energy hydrogen species.

17. A compound of claim 1 having a formula $[KHKNO_3]_n$ characterized in that n is an integer, and the hydrogen content H of the compound comprises at least one said increased binding energy hydrogen species.

18. A compound of claim 1 having a formula $[KHKOH]_n$ characterized in that n is an integer and the hydrogen content H of the compound comprises at least one said increased binding energy hydrogen species.

19. A compound of claim 1 having a formula $[MH_mM'X]_n$ characterized in that m and n are each an integer, M and M' are each an alkali or alkaline earth cation, X is a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least one said increased binding energy hydrogen species.

20. A compound of claim 1 having a formula $[MH_mM'X']_n^{m^{\cdot+}}$ $n'\,X^-$ characterized in that m, m', n, and n' are each an integer, M and M' are each an alkali or alkaline earth cation, X and X' are a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least one said increased binding energy hydrogen species.

21. A compound of claim 1 having a formula $[MH_mM'X']_n^{m^{\cdot-}}$ $n'\,M''^+$ characterized in that m, m', n, and n' are each an integer, M, M', and M'' are each an alkali or alkaline earth cation, X and X' are each a singly negative charged anion, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species.

22. A compound of claim 1 having a formula $\left[MH_m\right]_n^{m'+} n' X^-$ characterized in that m, m', n, and n' are each an integer, M is alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, X is a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species.

23. A compound of claim 1 having a formula $\left[MH_m\right]_n^{m'-} n' M^+$ characterized in that m, m', n, and n' are each an integer, M and M' are an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, the compound contains at least one H, and the hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species.

24. A compound of claim 1 having a formula $M(H_{10})_n$ characterized in that n is an integer, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_{16})_n$ of the compound comprises at least one increased binding energy hydrogen species.

25. A compound of claim 1 having a formula $M(H_{10})_n$ characterized in that n is an integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{16})_n$ of the compound comprises at least one increased binding energy hydrogen species.

26. A compound of claim 1 having a formula $M^+(H_{16})_n^-$ characterized in that n is an integer, M is other element such as an alkali, organic, organometalic, inorganic, or ammonium cation, and the hydrogen content $(H_{16})_n^-$ of the compound comprises at least one increased binding energy hydrogen species.

27. A compound of claim 1 having a formula $M^+(H_{16})_n^-$ characterized in that n is an integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{16})_n^-$ of the compound comprises at least one increased binding energy hydrogen species.

28. A compound of claim 1 having a formula $M(H_{16})_n$ characterized in that n is an integer, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_{16})_n$ of the compound comprises at

5 least one increased binding energy hydrogen species.

29. A compound of claim 1 having a formula $M(H_{16})_n$ characterized in that n is an integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{16})_n$ of the compound comprises at

10 least one increased binding energy hydrogen species.

30. A compound of claim 1 having a formula $M(H_{24})_n$ characterized in that n is an integer, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_{24})_n$ of the compound comprises at

15 least one increased binding energy hydrogen species.

31. A compound of claim 1 having a formula $M(H_{24})_n$ characterized in that n is an integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{24})_n$ of the compound comprises at

20 least one increased binding energy hydrogen species.

32. A compound of claim 1 having a formula $M(H_{60})_n$ characterized in that n is an integer, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_{60})_n$ of the compound comprises at

25 least one increased binding energy hydrogen species.

33. A compound of claim 1 having a formula $M(H_{60})_n$ characterized in that n is an integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{60})_n$ of the compound comprises at

30 least one increased binding energy hydrogen species.

34. A compound of claim 1 having a formula $M(H_{70})_n$ characterized in that n is an integer, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_{70})_n$ of the compound comprises at

35 least one increased binding energy hydrogen species.

129

35. A compound of claim 1 having a formula $M(H_{70})_n$ characterized in that n is an integer, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{70})_n$ of the compound comprises at least one increased binding energy hydrogen species.

36. A compound of claim 1 having a formula $M(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ characterized in that q, r, s, t, and u are each an integer including zero but not all zero, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ of the compound comprises at least one increased binding energy hydrogen species.

37. A compound of claim 1 having a formula $M(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ characterized in that q, r, s, and t are each an integer including zero but not all zero, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_t(H_{70})_u$ of the compound comprises at least one increased binding energy hydrogen species.

38. A compound of claim 1 having a formula MX characterized in that M is positive, neutral, or negative and is selected from the list of H_{16}, $H_{16}H$, $H_{16}H_2$, $H_{24}H_{23}$, OH_{22}, OH_{23}, OH_{24}, MgH_2H_{16}, NaH_3H_{16}, $H_{24}H_2O$, CNH_{16}, CH_{30}, SiH_4H_{16}, $(H_{16})_3H_{15}$, $SiH_4(H_{16})_2$, $(H_{16})_4$, H_{70}, $Si_2H_6H_{16}$, $(SiH_4)_2H_{16}$, $SiH_4(H_{16})_3$, CH_{70}, NH_{69}, NH_{70}, NHH_{70}, OH_{70}, H_2OH_{70}, FH_{70}, H_3OH_{70}, SiH_2H_{60}, $Si(H_{16})_3H_{15}$, $Si(H_{16})_4$, $Si_2H_6(H_{16})_2$, $Si_2H_7(H_{16})_2$, $SiH_3(H_{16})_4$, $(SiH_4)_2(H_{16})_2$, $O_2(H_{16})_4$, $SiH_4(H_{16})_4$, NOH_{70}, O_2H_{69}, $HONH_{70}$, O_2H_{70}, H_2ONH_{70}, $H_3O_2H_{70}$, $Si_2H_6(H_{24})_2$, $Si_2H_6(H_{16})_3$, $(SiH_4)_3H_{16}$, $(SiH_4)_2(H_{16})_3$, $(OH_{23})H_{16}H_{70}$, $(OH_{24})H_{16}H_{70}$, $Si_3H_{10}(H_{16})_2$, Si_2H_{70}, $Si_3H_{11}(H_{16})_2$, $Si_2H_7(H_{16})_4$, $(SiH_4)_3(H_{16})_2$, $(SiH_4)_2(H_{16})_4$, $NaOSiH_2(H_{16})_4$, $NaKHH_{70}$, $Si_2H_7(H_{70})$, $Si_3H_9(H_{16})_3$, $Si_3H_{10}(H_{16})_3$, $Si_2H_6(H_{16})_5$, $(SiH_4)_4H_{16}$, $(SiH_4)_3(H_{16})_3$, $Na_2OSiH_2(H_{16})_4$, $Si_3H_8(H_{16})_4$, Na_2KHH_{70}, $Si_3H_9(H_{16})_4$, Na_2HKHH_{70}, $SO(H_{16})_6(H_{15})$, $SH_2(OH_{23})H_{16}H_{70}$, $SO(H_{16})_7$, $Mg_2H_2H_{23}H_{16}H_{70}$, $(SiH_4)_4(H_{16})_2$, $(SiH_4)_3(H_{16})_4$, $KH_3O(H_{16})_2H_{70}$, $KH_5O(H_{16})_2H_{70}$, $K(OH_{23})H_{16}H_{70}$, K_2OHH_{70}, $NaKHO_2H_{70}$, $NaOHNaO_2H_{70}$, $HNO_3O_2H_{70}$, $Rb(H_{16})_5$, $Si_3H_{11}H_{70}$, $KNO_2(H_{16})_5$, $(SiH_4)_4(H_{16})_3$, $KKH(H_{16})_7$, $(SiH_4)_4(H_{16})_4$, $(KH_2)_2(H_{16})_3H_{70}$, $(NiH_2)_2HCl(H_{16})_2H_{70}$, Si_5OH_{102}, $(SiH_3)_7(H_{16})_5$, $Na_3O_3(SiH_3)_{10}SiH(H_{16})_5$,

X is other element, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen.

39.   A compound of claim 1 having a formula MX characterized in that M is positive, neutral, or negative and is selected from the list of H_{16}, $H_{16}H$, $H_{16}H_2$, $H_{24}H_{23}$, OH_{22}, OH_{23}, OH_{24}, MgH_2H_{16}, NaH_3H_{16}, $H_{24}H_2O$, CNH_{16}, CH_{30}, SiH_4H_{16}, $(H_{16})_3H_{15}$, $SiH_4(H_{16})_2$, $(H_{16})_4$, H_{70}, $Si_2H_6H_{16}$, $(SiH_4)_2H_{16}$, $SiH_4(H_{16})_3$, CH_{70}, NH_{69}, NH_{70}, NHH_{70}, OH_{70}, H_2OH_{70}, FH_{70}, H_3OH_{70}, SiH_2H_{60}, $Si(H_{16})_3H_{15}$, $Si(H_{16})_4$, $Si_2H_6(H_{16})_2$, $Si_2H_7(H_{16})_2$, $SiH_3(H_{16})_4$, $(SiH_4)_2(H_{16})_2$, $O_2(H_{16})_4$, $SiH_4(H_{16})_4$, NOH_{70}, O_2H_{69}, $HONH_{70}$, O_2H_{70}, H_2ONH_{70}, $H_3O_2H_{70}$, $Si_2H_6(H_{24})_2$, $Si_2H_6(H_{16})_3$, $(SiH_4)_3H_{16}$, $(SiH_4)_2(H_{16})_3$, $(OH_{23})H_{16}H_{70}$, $(OH_{24})H_{16}H_{70}$, $Si_3H_{10}(H_{16})_2$, Si_2H_{70}, $Si_3H_{11}(H_{16})_2$, $Si_2H_7(H_{16})_4$, $(SiH_4)_3(H_{16})_2$, $(SiH_4)_2(H_{16})_4$, $NaOSiH_2(H_{16})_4$, $NaKHH_{70}$, $Si_2H_7(H_{70})$, $Si_3H_9(H_{16})_3$, $Si_3H_{10}(H_{16})_3$, $Si_2H_6(H_{16})_5$, $(SiH_4)_4H_{16}$, $(SiH_4)_3(H_{16})_3$, $Na_2OSiH_2(H_{16})_4$, $Si_3H_8(H_{16})_4$, Na_2KHH_{70}, $Si_3H_9(H_{16})_4$, Na_2HKHH_{70}, $SO(H_{16})_6(H_{15})$, $SH_2(OH_{23})H_{16}H_{70}$, $SO(H_{16})_7$, $Mg_2H_2H_{23}H_{16}H_{70}$, $(SiH_4)_4(H_{16})_2$, $(SiH_4)_3(H_{16})_4$, $KH_3O(H_{16})_2H_{70}$, $KH_5O(H_{16})_2H_{70}$, $K(OH_{23})H_{16}H_{70}$, K_2OHH_{70}, $NaKHO_2H_{70}$, $NaOHNaO_2H_{70}$, $HNO_3O_2H_{70}$, $Rb(H_{16})_5$, $Si_3H_{11}H_{70}$, $KNO_2(H_{16})_5$, $(SiH_4)_4(H_{16})_3$, $KKH(H_{16})_7$, $(SiH_4)_4(H_{16})_4$, $(KH_2)_2(H_{16})_3H_{70}$, $(NiH_2)_2HCl(H_{16})_2H_{70}$, Si_5OH_{102}, $(SiH_3)_7(H_{16})_5$, $Na_3O_3(SiH_3)_{10}SiH(H_{16})_5$, X is an increased binding energy hydrogen compound, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen.
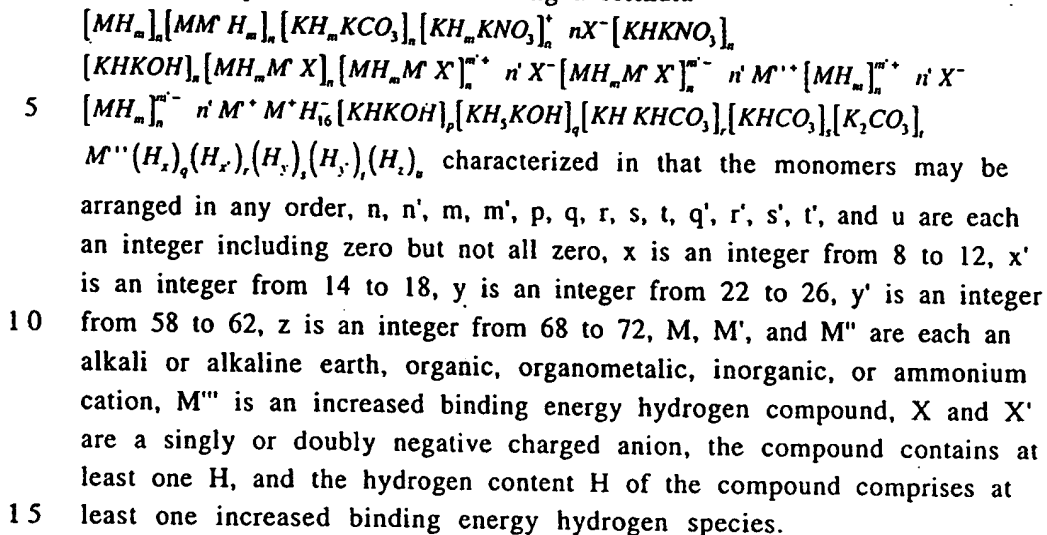
40.   A compound of claim 1 having a formula $M(H_x)_n$ characterized in that n is an integer, x is an integer from 8 to 12, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

41.   A compound of claim 1 having a formula $M(H_x)_n$ characterized in that n is an integer, x is an integer from 8 to 12, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

42. A compound of claim 1 having a formula $M^+(H_x)_n^-$ characterized in that n is an integer, x is an integer from 14 to 18, M is other element such as an alkali, organic, organometalic, inorganic, or ammonium cation, and the hydrogen content $(H_x)_n^-$ of the compound comprises at least one

5   increased binding energy hydrogen species.

43. A compound of claim 1 having a formula $M^+(H_x)_n^-$ characterized in that n is an integer, x is an integer from 14 to 18, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n^-$ of

10   the compound comprises at least one increased binding energy hydrogen species.

44. A compound of claim 1 having a formula $M(H_x)_n$ characterized in that n is an integer, x is an integer from 14 to 18, M is other element such

15   as any atom, molecule, or compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

45. A compound of claim 1 having a formula $M(H_x)_n$ characterized in

20   that n is an integer, x is an integer from 14 to 18, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

25   46. A compound of claim 1 having a formula $M(H_x)_n$ characterized in that n is an integer, x is an integer from 22 to 26, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

30

47. A compound of claim 1 having a formula $M(H_x)_n$ characterized in that n is an integer, x is an integer from 22 to 26, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen

35   species.

132

48.　A compound of claim 1 having a formula $M(H_x)_n$ characterized in that n is an integer, x is an integer from 58 to 62, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_x)_n$ of

5　the compound comprises at least one increased binding energy hydrogen species.

49.　A compound of claim 1 having a formula $M(H_x)_n$ characterized in that n is an integer, x is an integer from 58 to 62, M is an increased

10　binding energy hydrogen compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

50.　A compound of claim 1 having a formula $M(H_x)_n$ characterized in

15　that n is an integer, x is an integer from 68 to 72, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species

20　51.　A compound of claim 1 having a formula $M(H_x)_n$ characterized in that n is an integer, x is an integer from 68 to 72, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_n$ of the compound comprises at least one increased binding energy hydrogen species.

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52.　A compound of claim 1 having a formula $M(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ characterized in that the monomers may be arranged in any order, q, r, s, t, and u are each an integer including zero but not all zero, x is an integer from 8 to 12, x' is an integer from 14 to 18, y is an integer from 22 to 26,

30　y' is an integer from 58 to 62, z is an integer from 68 to 72, M is other element such as any atom, molecule, or compound, and the hydrogen content $(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ of the compound comprises at least one increased binding energy hydrogen species.

133

53. A compound of claim 1 having a formula $M(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ characterized in that the monomers may be arranged in any order, q, r, s, t, and u are each an integer including zero but not all zero, x is an integer from 8 to 12, x' is an integer from 14 to 18, y is an integer from 22 to 26,

5   y' is an integer from 58 to 62, z is an integer from 68 to 72, M is an increased binding energy hydrogen compound, and the hydrogen content $(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ of the compound comprises at least one increased binding energy hydrogen species.

10 54. A compound of claim 1 having a formula
$[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$ characterized in that the monomers may be arranged in any order, p, q, r, s, and t are each an integer including zero but not all zero, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one

15 increased binding energy hydrogen.

55. A compound of claim 1 having a formula
$[MH_m]_n[MM'\,H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+\,nX^-[KHKNO_3]_n$
$[KHKOH]_n[MH_mM'\,X]_n[MH_mM'\,X]_n^{m'+}\,n'\,X^-[MH_mM'\,X]_n^{m'-}\,n'\,M'^{+}[MH_m]_n^{m'+}\,n'\,X^-$

20 $[MH_m]_n^{m'-}\,n'\,M'^{+}\,M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$ characterized in that the monomers may be arranged in any order, n, n', m, m', p, q, r, s, and t are each an integer including zero but not all zero, M, M', and M'' are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, X and X' are a singly or doubly negative

25 charged anion, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

56. A compound of claim 1 having a formula

30 $[MH_m]_n[MM'\,H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^+\,nX^-[KHKNO_3]_n$
$[KHKOH]_n[MH_mM'\,X]_n[MH_mM'\,X]_n^{m'+}\,n'\,X^-[MH_mM'\,X]_n^{m'-}\,n'\,M'^{+}[MH_m]_n^{m'+}\,n'\,X^-$
$[MH_m]_n^{m'-}\,n'\,M'^{+}\,M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$
$M''(H_{10})_{q'}(H_{16})_{r'}(H_{24})_{s'}(H_{60})_{r}(H_{70})_u$ characterized in that the monomers may be arranged in any order, n, n', m, m', p, q, r, s, t, q', r', s', t', and u are each

134

an integer including zero but not all zero, M, M', and M" are each an alkali
or alkaline earth, organic, organometalic, inorganic, or ammonium cation,
M''' is other element, X and X' are a singly or doubly negative charged
anion, the compound contains at least one H, and the hydrogen content H

5   of the compound comprises at least one increased binding energy
hydrogen species.

57.   A compound of claim 1 having a formula

$[MH_m]_n[MM'H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^*$ $nX^-[KHKNO_3]_n$

10 $[KHKOH]_n[MH_mM'X]_n[MH_mM'X']_n^{m'+}$ $n'X^-[MH_mM'X']_n^{m'-}$ $n'M'^+[MH_m]_n^{m'+}$ $n'X^-$

$[MH_m]_n^{m'-}$ $n'M^+$ $M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_q[KHCO_3]_s[K_2CO_3]_t$

$M'''(H_{10})_q(H_{16})_r(H_{24})_s(H_{60})_r(H_{70})_u$ characterized in that the monomers may be

arranged in any order, n, n', m, m', p, q, r, s, t, q', r', s', t', and u are each
an integer including zero but not all zero, M, M', and M" are each an alkali

15 or alkaline earth, organic, organometalic, inorganic, or ammonium cation,
M''' is an increased binding energy hydrogen compound, X and X' are a
singly or doubly negative charged anion, the compound contains at least
one H, and the hydrogen content H of the compound comprises at least
one increased binding energy hydrogen species.

20

58.   A compound of claim 1 having a formula

$[MH_m]_n[MM'H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^*$ $nX^-[KHKNO_3]_n$

$[KHKOH]_n[MH_mM'X]_n[MH_mM'X']_n^{m'+}$ $n'X^-[MH_mM'X']_n^{m'-}$ $n'M'^+[MH_m]_n^{m'+}$ $n'X^-$

$[MH_m]_n^{m'-}$ $n'M^+$ $M^+H_{16}^-[KHKOH]_p[KH_5KOH]_q[KH\,KHCO_3]_q[KHCO_3]_s[K_2CO_3]_t$

25 $M'''(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ characterized in that the monomers may be

arranged in any order, n, n', m, m', p, q, r, s, t, q', r', s', t', and u are each
an integer including zero but not all zero, x is an integer from 8 to 12, x'
is an integer from 14 to 18, y is an integer from 22 to 26, y' is an integer
from 58 to 62, z is an integer from 68 to 72, M, M', and M" are each an

30 alkali or alkaline earth, organic, organometalic, inorganic, or ammonium
cation, M''' is other element, X and X' are a singly or doubly negative
charged anion, the compound contains at least one H, and the hydrogen
content H of the compound comprises at least one increased binding
energy hydrogen species.

135

59. A compound of claim 1 having a formula

$[MH_m]_n [MM' H_m]_n [KH_m KCO_3]_n [KH_m KNO_3]_n^+ nX^- [KHKNO_3]_n$

$[KHKOH]_n [MH_m M' X]_n [MH_m M' X]_n^{m'+} n' X^- [MH_m M' X]_n^{m'-} n' M'^+ [MH_m]_n^{m'+} n' X^-$

5   $[MH_m]_n^{m'-} n' M'^+ M^+ H_{16}^- [KHKOH]_p [KH_s KOH]_q [KH\ KHCO_3]_r [KHCO_3]_s [K_2CO_3]_t$

$M'''(H_x)_q (H_{x'})_r (H_y)_s (H_{y'})_t (H_z)_u$ characterized in that the monomers may be arranged in any order, n, n', m, m', p, q, r, s, t, q', r', s', t', and u are each an integer including zero but not all zero, x is an integer from 8 to 12, x' is an integer from 14 to 18, y is an integer from 22 to 26, y' is an integer

10 from 58 to 62, z is an integer from 68 to 72, M, M', and M" are each an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, M"' is an increased binding energy hydrogen compound, X and X' are a singly or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H of the compound comprises at

15 least one increased binding energy hydrogen species.

60. A compound of claim 1 having a formula

$[MH_m]_n [MM' H_m]_n [KH_m KCO_3]_n [KH_m KNO_3]_n^+ nX^- [KHKNO_3]_n$

$[KHKOH]_n [MH_m M' X]_n [MH_m M' X]_n^{m'+} n' X^- [MH_m M' X]_n^{m'-} n' M'^+ [MH_m]_n^{m'+} n' X^-$

20 $[MH_m]_n^{m'-} n' M'^+ M^+ H_{16}^- [KHKOH]_p [KH_s KOH]_q [KH\ KHCO_3]_r [KHCO_3]_s [K_2CO_3]_t$

$M'''(H_x)_q (H_{x'})_r (H_y)_s (H_{y'})_t (H_z)_u$ characterized in that the monomers may be arranged in any order, n, n', m, m', p, q, r, s, t, q', r', s', t', and u are each an integer including zero but not all zero, x is an integer from 8 to 12, x' is an integer from 14 to 18, y is an integer from 22 to 26, y' is an integer

25 from 58 to 62, z is an integer from 68 to 72, M, M' and M" are each a metal such as silicon, aluminum, Group III A elements, Group IVA elements, a transition metal, inner transition metal, tin, boron, or a rare earth, lanthanide, an alkali or alkaline earth, organic, organometalic, inorganic, or ammonium cation, M"' is other element, X and X' are a singly

30 or doubly negative charged anion, the compound contains at least one H, and the hydrogen content H of the compound comprises at least one increased binding energy hydrogen species.

61.   A compound of claim 1 having a formula

$$[MH_m]_n[MM'H_m]_n[KH_mKCO_3]_n[KH_mKNO_3]_n^* nX^-[KHKNO_3]_n$$
$$[KHKOH]_n[MH_mM'X]_n[MH_mM'X']_n^{m'+} n'X^-[MH_mM'X']_n^{m'-} n'M'^+[MH_m]_n^{m'+} n'X^-$$
$$[MH_m]_n^{m'-} n'M'^+ M'H_{16}^-[KHKOH]_p[KH_sKOH]_q[KH KHCO_3]_r[KHCO_3]_s[K_2CO_3]_t$$

$M'''(H_x)_q(H_{x'})_r(H_y)_s(H_{y'})_t(H_z)_u$ characterized in that the monomers may be
arranged in any order, n, n', m, m', p, q, r, s, t, q', r', s', t', and u are each
an integer including zero but not all zero, x is an integer from 8 to 12, x'
is an integer from 14 to 18, y is an integer from 22 to 26, y' is an integer
from 58 to 62, z is an integer from 68 to 72, M, M' and M" are each a
metal such as silicon, aluminum, Group III A elements, Group IVA
elements, a transition metal, inner transition metal, tin, boron, or a rare
earth, lanthanide, an alkali or alkaline earth, organic, organometalic,
inorganic, or ammonium cation, M''' is an increased binding energy
hydrogen compound, X and X' are a singly or doubly negative charged
anion, the compound contains at least one H, and the hydrogen content H
of the compound comprises at least one increased binding energy
hydrogen species.

62.   A compound of claim 1 having a formula $Si_xH_y(H_{16})_z$ characterized in
that x is an integer, y is an integer from 2x+2 to 4x, z is an integer, and
the hydrogen content H of the compound comprises at least one increased
binding energy hydrogen species.

63.   A compound of claim 16 characterized in that said singly negative
charged anion is selected from the group consisting of halogen ions,
hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and
nitrate ion.

64.   A compound of claim 19 characterized in that said singly negative
charged anion is selected from the group consisting of halogen ion,
hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and
nitrate ion.

65.   A compound of claim 20 characterized in that said singly negative
charged anion is selected from the group consisting of halogen ion,

137

hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and nitrate ion.

66. A compound of claim 21 characterized in that said singly negative
5   charged anion is selected from the group consisting of halogen ions, hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and nitrate ion.

67. A compound of claim 22 characterized in that said singly negative
10 charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and nitrate ion.

68. A compound of claim 55 characterized in that said singly negative
15 charged anion is selected from the group consisting of halogen ions, hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and nitrate ion.

69. A compound of claim 56 characterized in that said singly negative
20 charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and nitrate ion.

70. A compound of claim 57 characterized in that said singly negative
25 charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and nitrate ion.

71. A compound of claim 58 characterized in that said singly negative
30 charged anion is selected from the group consisting of halogen ions, hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and nitrate ion.

72. A compound of claim 59 characterized in that said singly negative
35 charged anion is selected from the group consisting of halogen ions,

138

hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and nitrate ion.

73.   A compound of claim 60 characterized in that said singly negative
5   charged anion is selected from the group consisting of halogen ions, hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and nitrate ion.

74.   A compound of claim 61 characterized in that said singly negative
10   charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, dihydrogen phosphate, and nitrate ion.

75.   A compound of claim 19 characterized in that said doubly negative
15   charged anion is selected from the group consisting of carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion.

76.   A compound of claim 20 characterized in that said doubly negative charged anion is selected from the group consisting of carbonate ion,
20   oxides, phosphates, hydrogen phosphates, and sulfate ion

77.   A compound of claim 22 characterized in that said doubly negative charged anion is selected from the group consisting of carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion
25

78.   A compound of claim 55 characterized in that said doubly negative charged anion is selected from the group consisting of carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion

30   79.   A compound of claim 56 characterized in that said doubly negative charged anion is selected from the group consisting of carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion

80.   A compound of claim 57 characterized in that said doubly negative
35   charged anion is selected from the group consisting of carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion

81. A compound of claim 58 characterized in that said doubly negative charged anion is selected from the group consisting of carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion

82. A compound of claim 59 characterized in that said doubly negative charged anion is selected from the group consisting of carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion

83. A compound of claim 60 characterized in that said doubly negative charged anion is selected from the group consisting of carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion

84. A compound of claim 61 characterized in that said doubly negative charged anion is selected from the group consisting of carbonate ion, oxides, phosphates, hydrogen phosphates, and sulfate ion

85. A compound comprising
    (a) at least one neutral, positive, or negative increased binding energy hydrogen species having a total energy
        (i) greater than the total energy of the corresponding ordinary hydrogen species, or
        (ii) greater than the total energy of any hydrogen species for which the corresponding ordinary hydrogen species is unstable or is not observed because the ordinary hydrogen species' total energy is less than thermal energies at ambient conditions, or is negative; and
    (b) at least one other element.

86. A method of separating a desired isotope from a mixture of isotopes:
        reacting an increased binding energy hydrogen species with an isotopic mixture comprising a molar excess of a desired isotope with respect to the increased binding energy hydrogen species to form a compound enriched in the desired isotope;
        separating said compound enriched in the desired isotope from the reaction mixture; and

140

separating the increased binding energy hydrogen species from the desired isotope to obtain the desired isotope.

87.   A method of separating a desired isotope from a mixture of
5   isotopes:

reacting a mixture of isotopes with an increased binding energy hydrogen species, and

removing said compound enriched in the undesired isotope.

10   88.   The method of claim 86 characterized in that the mixture of isotopes comprises elements and/or compounds containing the isotopes.

89.   The method of claim 87 characterized in that the mixture of isotopes comprises elements and/or compounds containing the isotopes.
15

90.   A method of separating isotopes according to any of claims 86-89 characterized in that the increased binding energy hydrogen species is an increased binding energy hydride ion.

20   91.   A method of separating isotopes according to claim 86, further comprising the steps of repeating said steps of reacting and separating until a desired level or enrichment is obtained.

92.   A method of separating isotopes according to claim 87,
25   characterized in that said increased binding energy hydrogen species is added in an amount less than the stoichiometric amount to fully react with said undesired isotope.

93.   A method of separating isotopes according to claim 92, further
30   comprising the steps of repeating said steps of reacting and removing until a desired level of enrichment is obtained.

94.   A method of separating isotopes according to claim 87, characterized in that said increased binding energy hydrogen species is
35   added in about the stiochiometric amount to fully react with said undesired isotope.

95. The compound of claim 1 that is a source of protons when thermally decomposed.

96. The compound of claim 1 that can be statically charged and comprises a component of a xerographic toner.

97. The compound of claim 1 that may be useful as a magnet or may comprise a magnetic computer memory storage material.

98. The hydrino atom of claim 1 that comprises an etching agent.

99. A method of forming the novel compounds of claim 1 comprising the steps of:

 providing a gaseous catalyst comprising at least one selected from the group consisting of atoms of Li, Be, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Kr, Rb, Sr, Nb, Mo, Pd, Sn, Te, Cs, Ce, Pr, Sm, Gd, Dy, Pb, and Pt;

 providing gaseous hydrogen atoms;

 reacting said gaseous catalyst with said gaseous hydrogen atoms, thereby forming hydrino from said gaseous hydrogen atoms;

 reacting said hydrino with at least one selected from the group of a source of electrons, H^+, increased binding energy hydrogen species, and other element to form said novel compounds.

100. A method of claim 99 of forming novel compounds characterized in that a gaseous catalysts comprises at least one selected from the group consisting of a source of K^+, a source of Rb^+, and a source of He^+.

101. A method of claim 100 of forming novel compounds characterized in that the source of K^+ is potassium metal.

102. A method of claim 100 of forming novel compounds characterized in that the source of Rb^+ is rubidium metal.

142

103. A method of claim 99 of forming novel compounds further comprising the step of applying an adjustable electric or magnetic field to control the rate of formation of hydrino.

5   104. A method for extracting energy from hydrogen atoms comprising the steps of:

providing a gaseous catalyst comprising at least one selected from the group consisting of atoms of Li, Be, K, Ca, Ti,
V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Kr, Rb, Sr, Nb, Mo, Pd, Sn, Te,
10   Cs, Ce, Pr, Sm, Gd, Dy, Pb, and Pt;

providing gaseous hydrogen atoms; and

reacting said gaseous catalyst with said gaseous hydrogen atoms, thereby releasing energy from said gaseous hydrogen atoms.

15

105. A method of claim 104 for extracting energy from hydrogen atoms characterized in that a gaseous catalysts comprises at least one selected from the group consisting of a source of K^+, a source of Rb^+, and a source of He^+.

20

106. A method of claim 105 for extracting energy from hydrogen atoms characterized in that the source of K^+ is potassium metal.

107. A method of claim 105 for extracting energy from hydrogen
25   atoms characterized in that the source of Rb^+ is rubidium metal.

108. A method of claim 104 for extracting energy from hydrogen atoms further comprising the step of applying an adjustable electric or magnetic field to control the rate of energy release.

30

109. A cell for extracting energy from hydrogen atoms comprising:

a reaction vessel;

a source of gaseous hydrogen atoms; and

a source of a gaseous catalyst comprising at least one
35   selected from the group consisting of atoms of Li, Be, K, Ca, Ti,

143

V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Kr, Rb, Sr, Nb, Mo, Pd, Sn, Te,
Cs, Ce, Pr, Sm, Gd, Dy, Pb, and Pt.

110. A cell of claim 109 for extracting energy from hydrogen atoms
characterized in that a gaseous catalysts comprises at least one
selected from the group consisting of a source of K^+, a source of Rb^+,
and a source of He^+.

111. A cell of claim 110 for extracting energy from hydrogen atoms
characterized in that the source of K^+ is potassium metal.

112. A cell of claim 110 for extracting energy from hydrogen atoms
characterized in that the source of Rb^+ is rubidium metal.

113. A cell of claim 109 for extracting energy from hydrogen atoms
further comprising an adjustable electric or magnetic field source.

114. A cell for extracting energy from hydrogen atoms comprising:
        a reaction vessel;
        a chamber communicating with said vessel, said chamber
containing gaseous hydrogen atoms or a source of said
hydrogen atoms; and
        a catalyst reservoir communicating with said reaction
vessel or a boat contained in said reaction vessel, said catalyst
reservoir or boat containing a gaseous catalyst comprising at
least one selected from the group consisting of atoms of Li, Be,
K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Kr, Rb, Sr, Nb, Mo,
Pd, Sn, Te, Cs, Ce, Pr, Sm, Gd, Dy, Pb, and Pt.

115. A cell of claim 114 for extracting energy from hydrogen atoms
characterized in that a gaseous catalysts comprises at least one
selected from the group consisting of a source of K^+, a source of Rb^+,
and a source of He^+.

116. A cell of claim 115 for extracting energy from hydrogen atoms
characterized in that the source of K^+ is potassium metal.

117. A cell of claim 115 for extracting energy from hydrogen atoms characterized in that the source of Rb^* is rubidium metal.

5   118. A cell of claim 114 for extracting energy from hydrogen atoms further comprising an adjustable electric or magnetic field source.
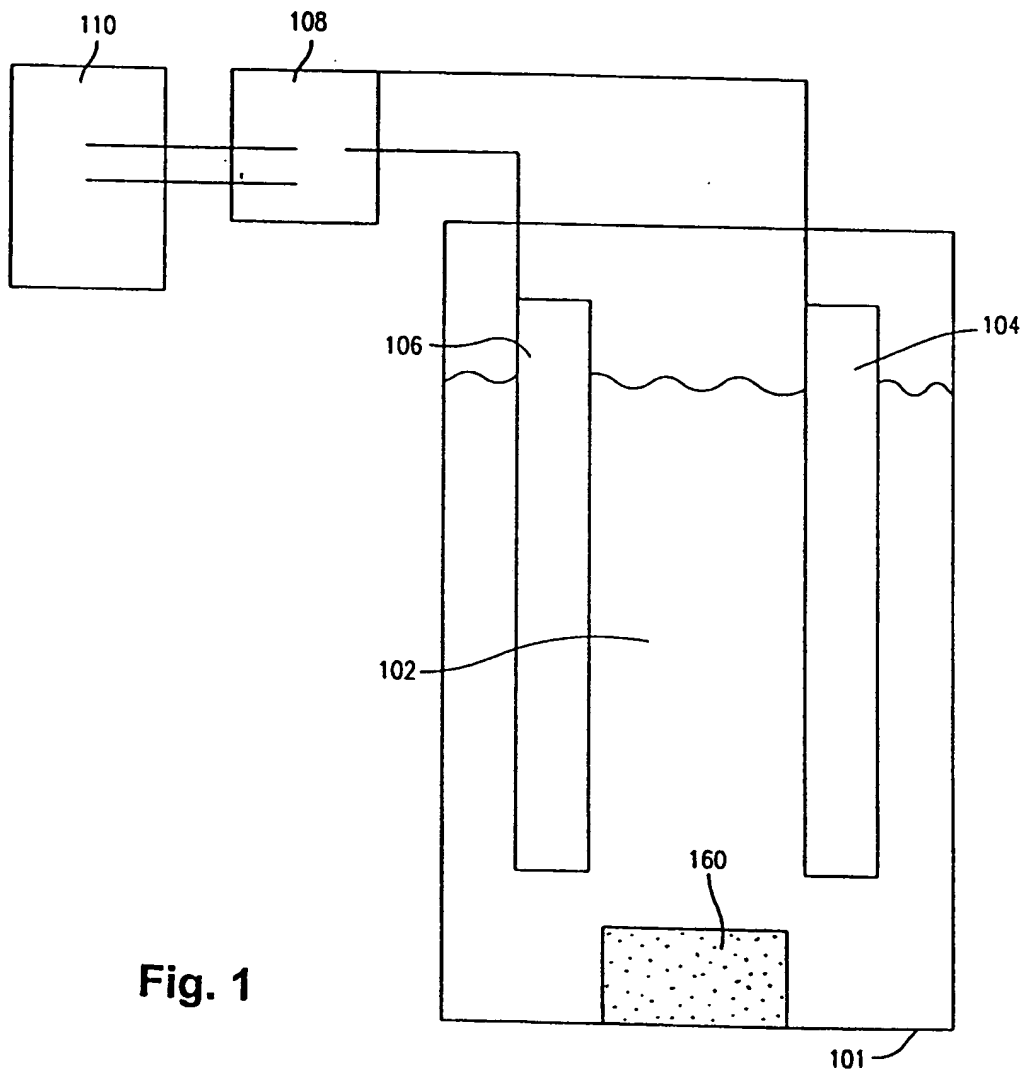
Fig. 1
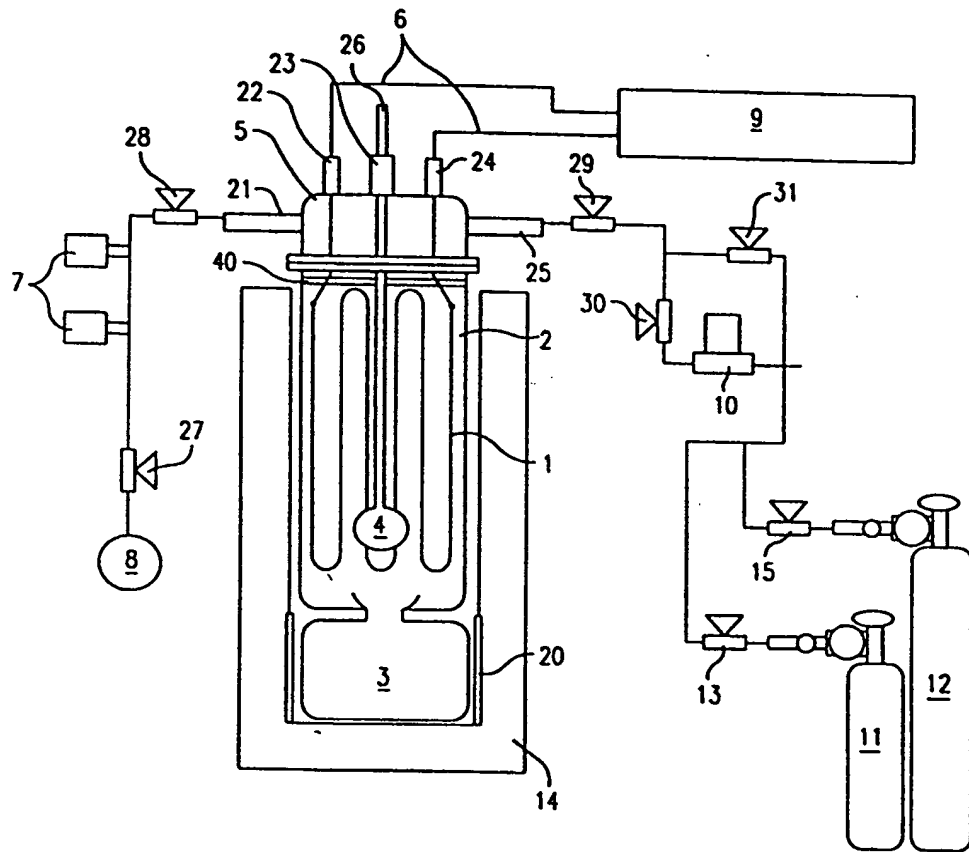
Fig. 2
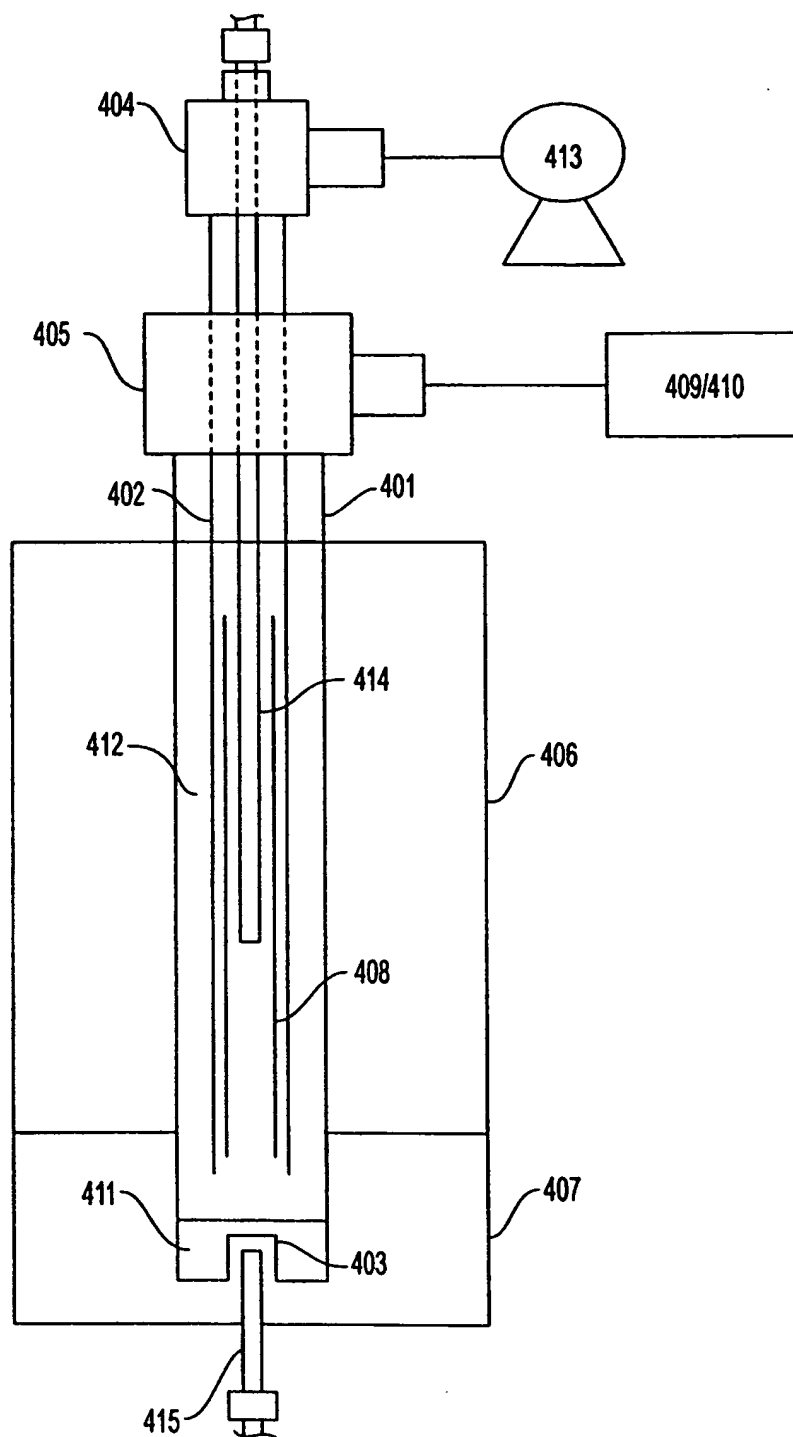
FIG. 3
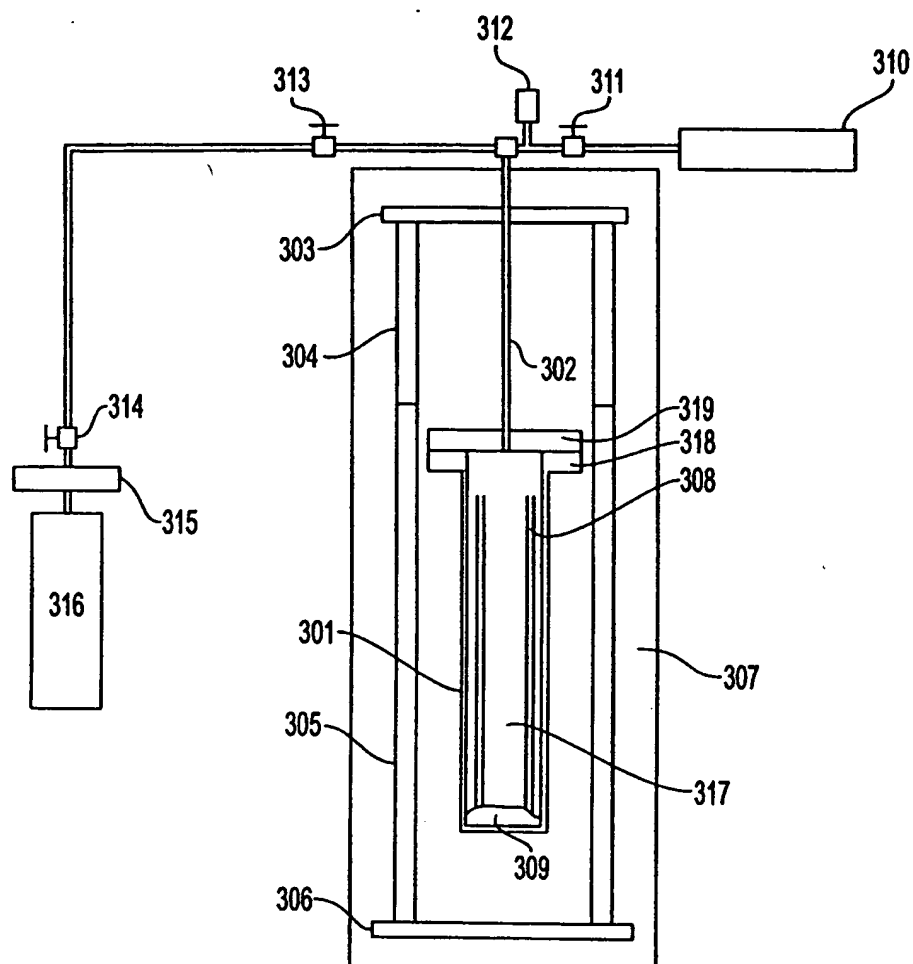
FIG. 4

FIG. 96A
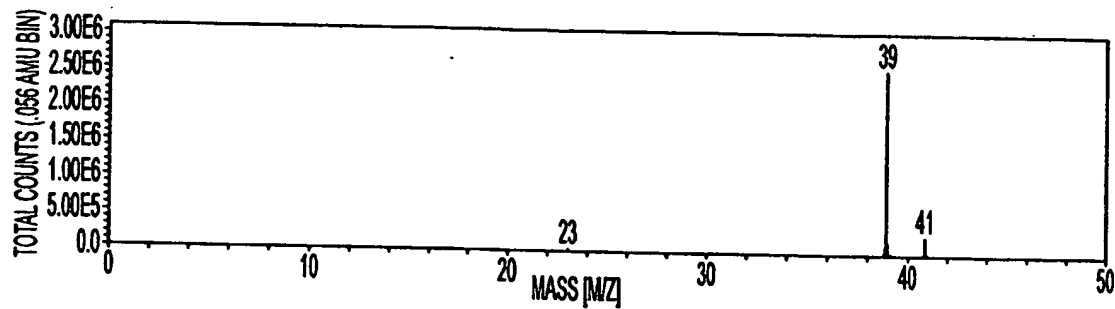
FIG. 96B
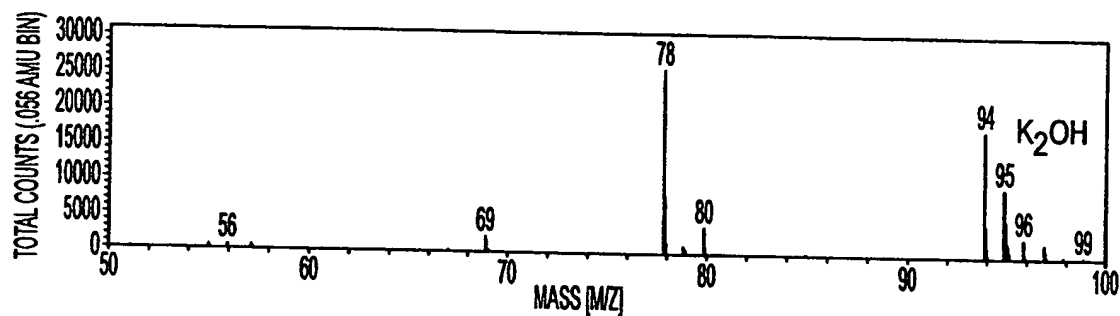
FIG. 96C
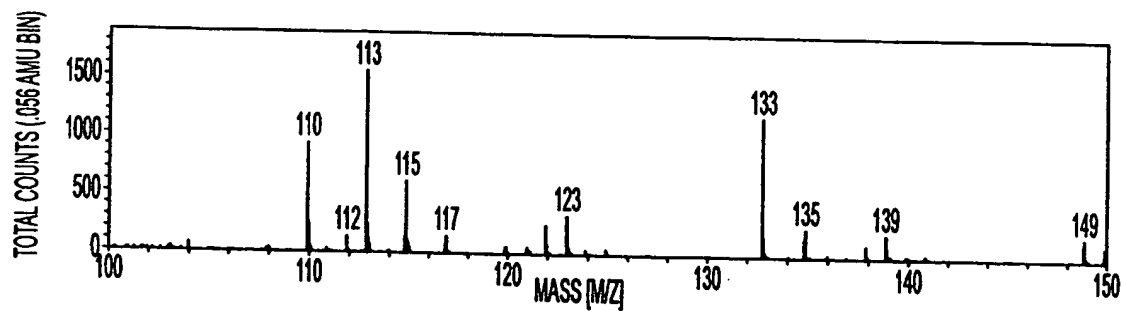
FIG. 96D
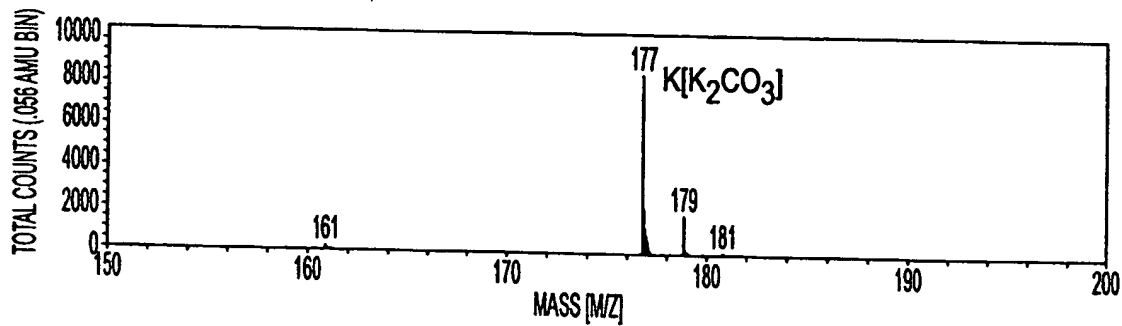
FIG. 97A
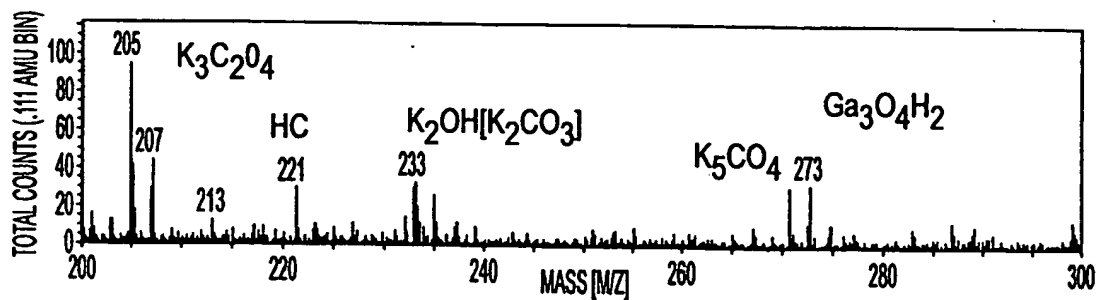
FIG. 97B
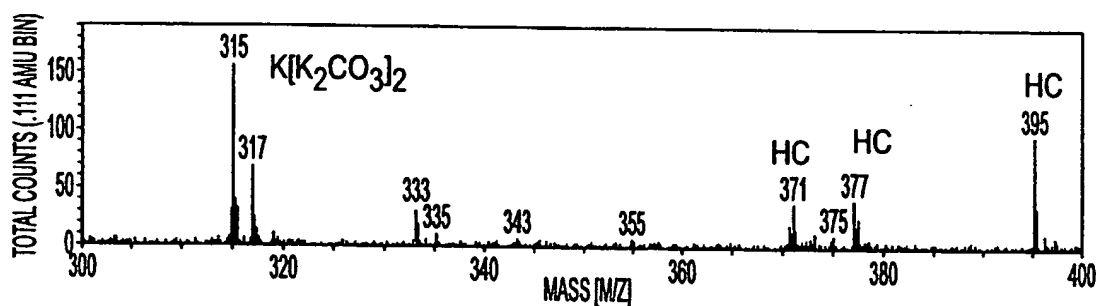
FIG. 97C
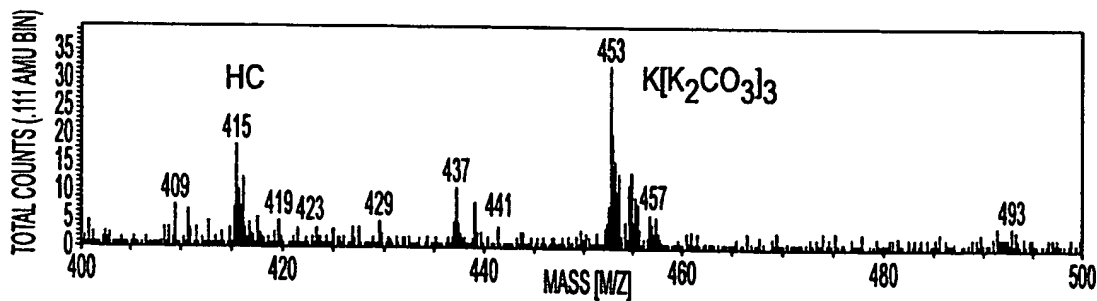
FIG. 97D
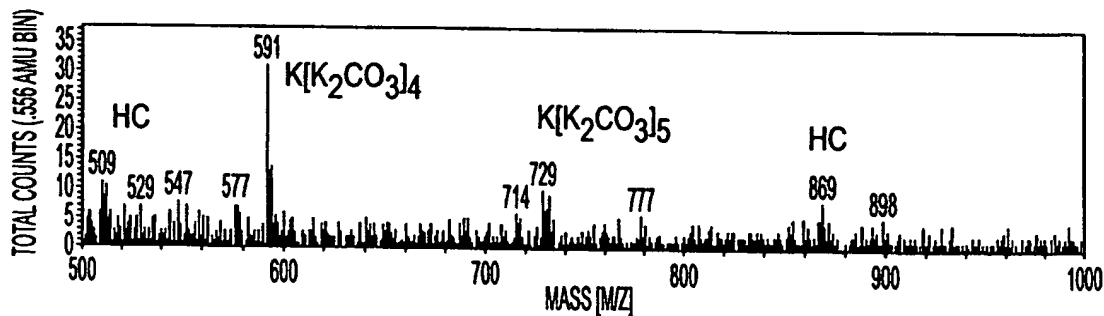
FIG. 98A
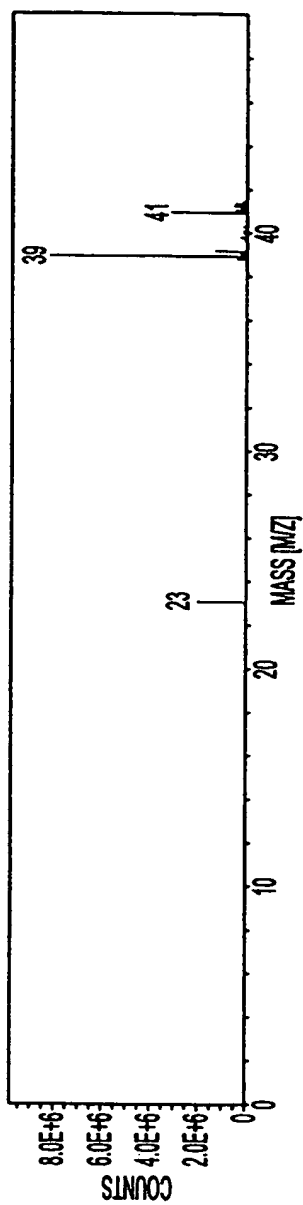
FIG. 98B
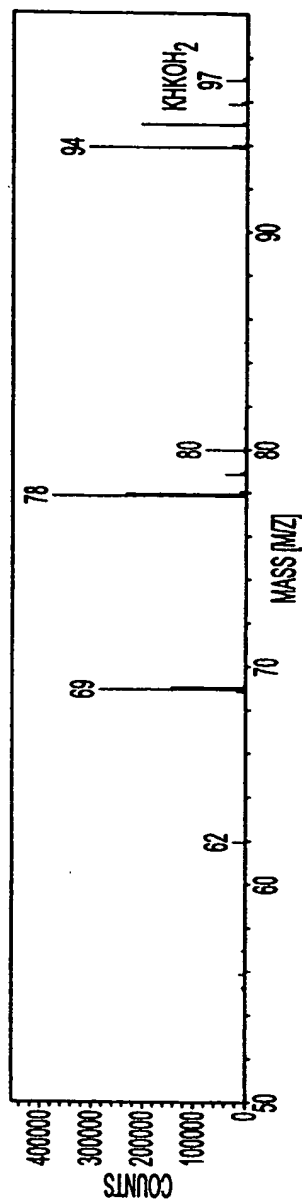
FIG. 98C
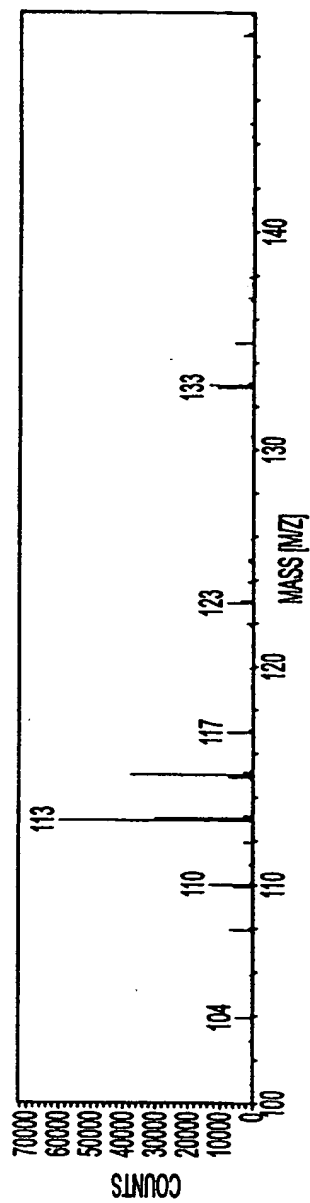
FIG. 98D
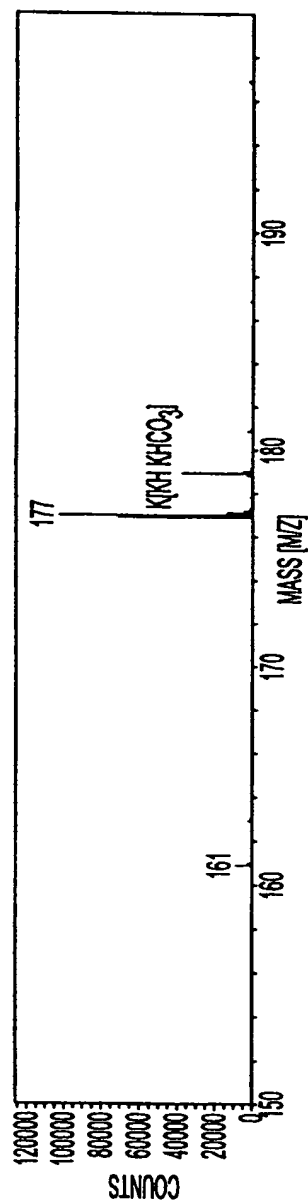
FIG. 99A

FIG. 99B

FIG. 99C

FIG. 99D

$H^-(1/2)$ 3 eV

$H^-(1/3)$ 6.6 eV

$H^-(1/4)$ 11.2 eV

$H^-(1/5)$ 16.7 eV

K 17.5 eV

$H^-(1/6)$ 22.8 eV

O 23 eV

$H^-(1/7)$ 29.3 eV

K 33.5 eV

$H^-(1/8)$ 36.1 eV

$H^-(1/9)$ 42.8 eV

$H^-(1/10)$ 49.4 eV

$H^-(1/11)$ 55.5 eV

$H^-(1/12)$ 61 eV

65.6 eV − 72.4 eV

$H^-(1/13) - H^-(1/16)$ {

Binding Energy [eV]

Fig. 100

[Counts]

100000

80000

60000

40000

20000

20

40

60
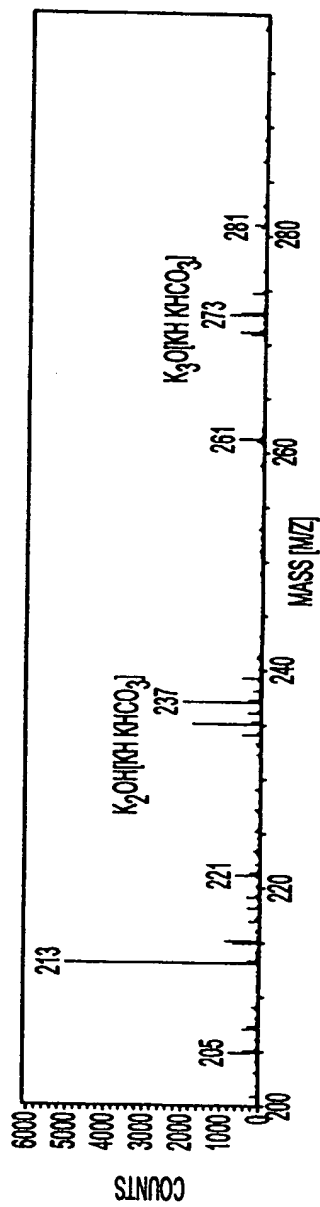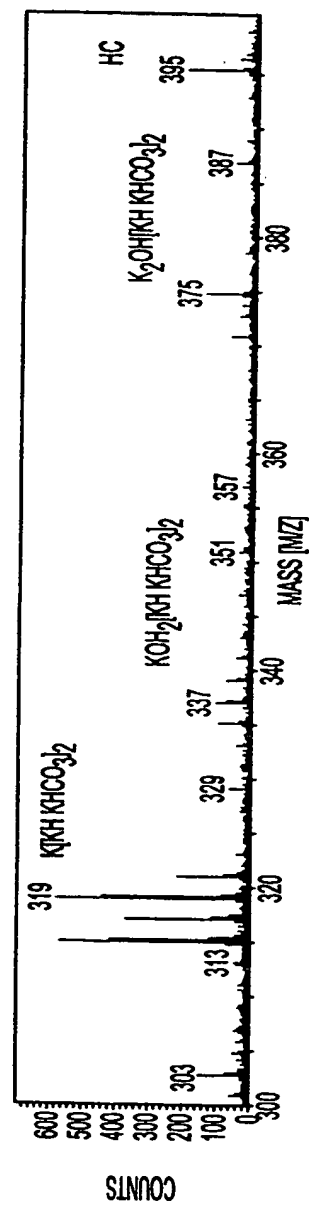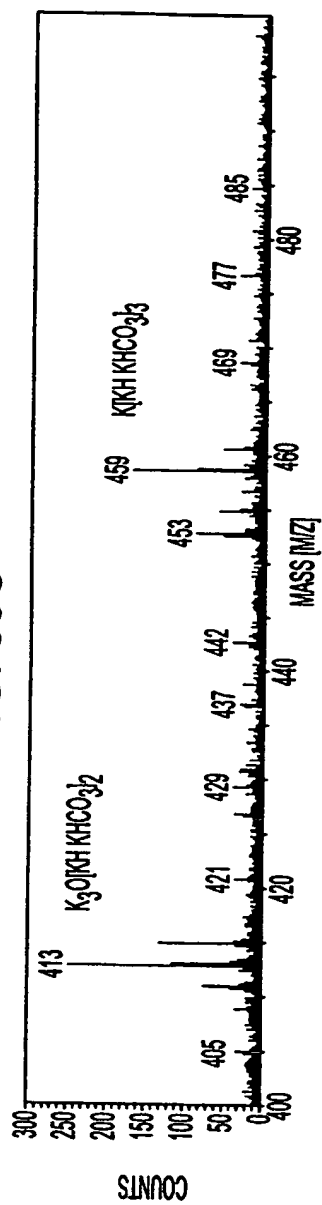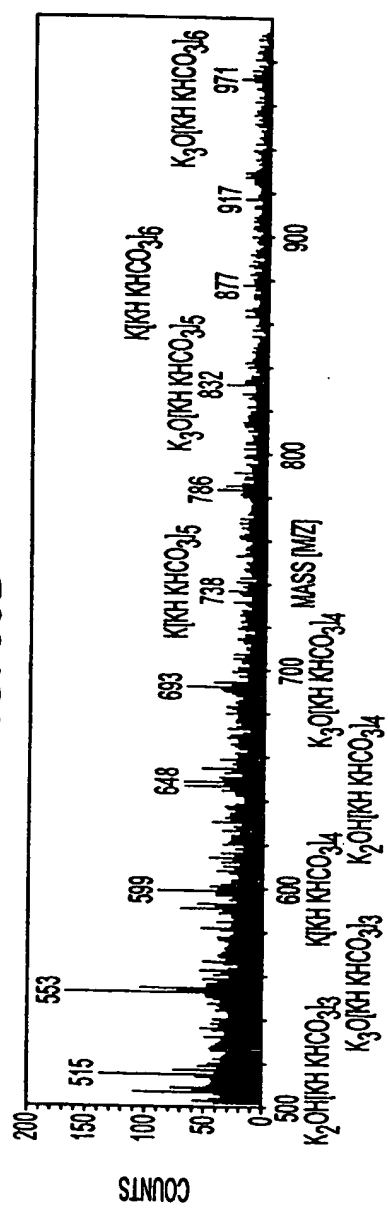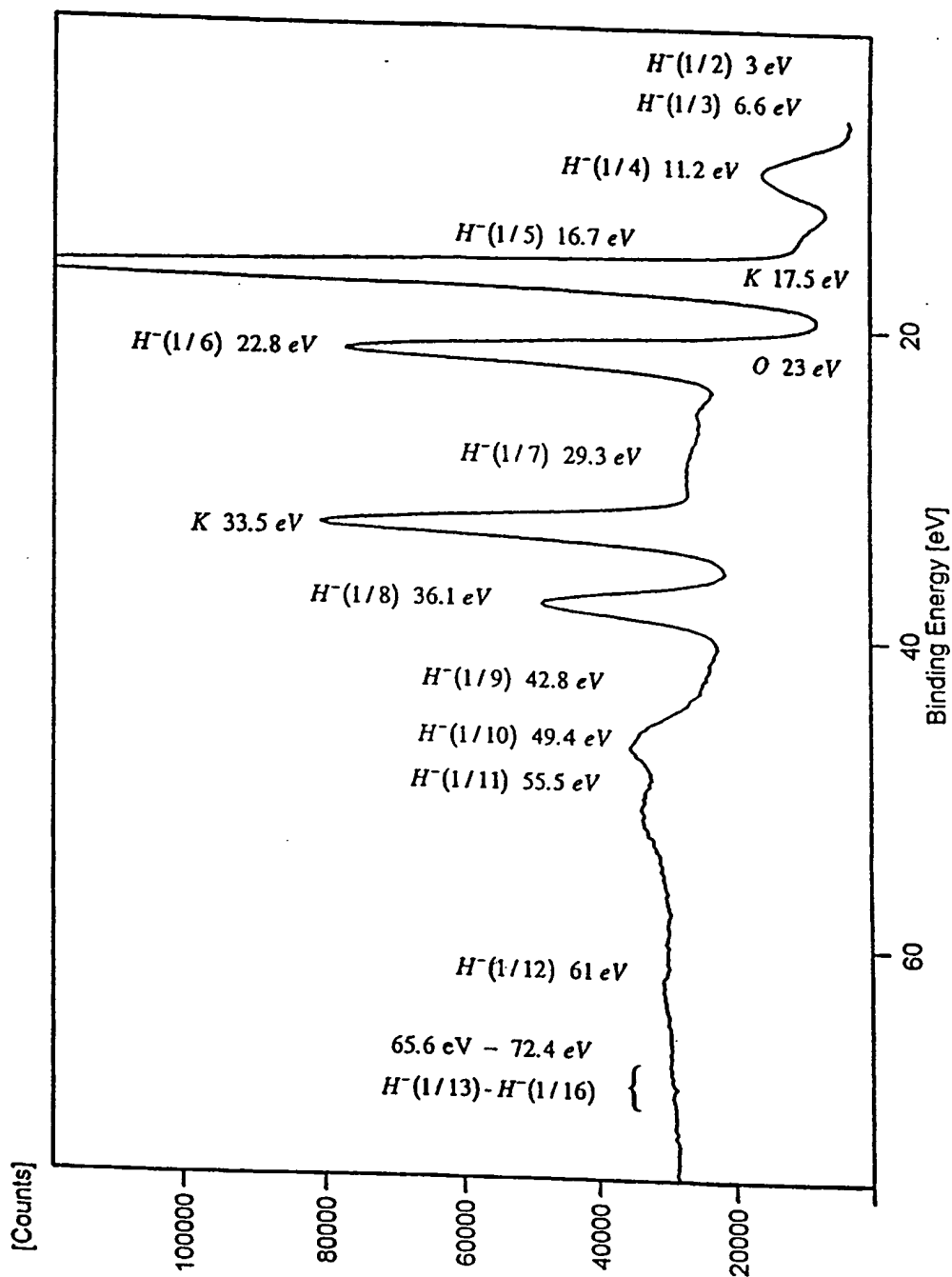
Fig. 101
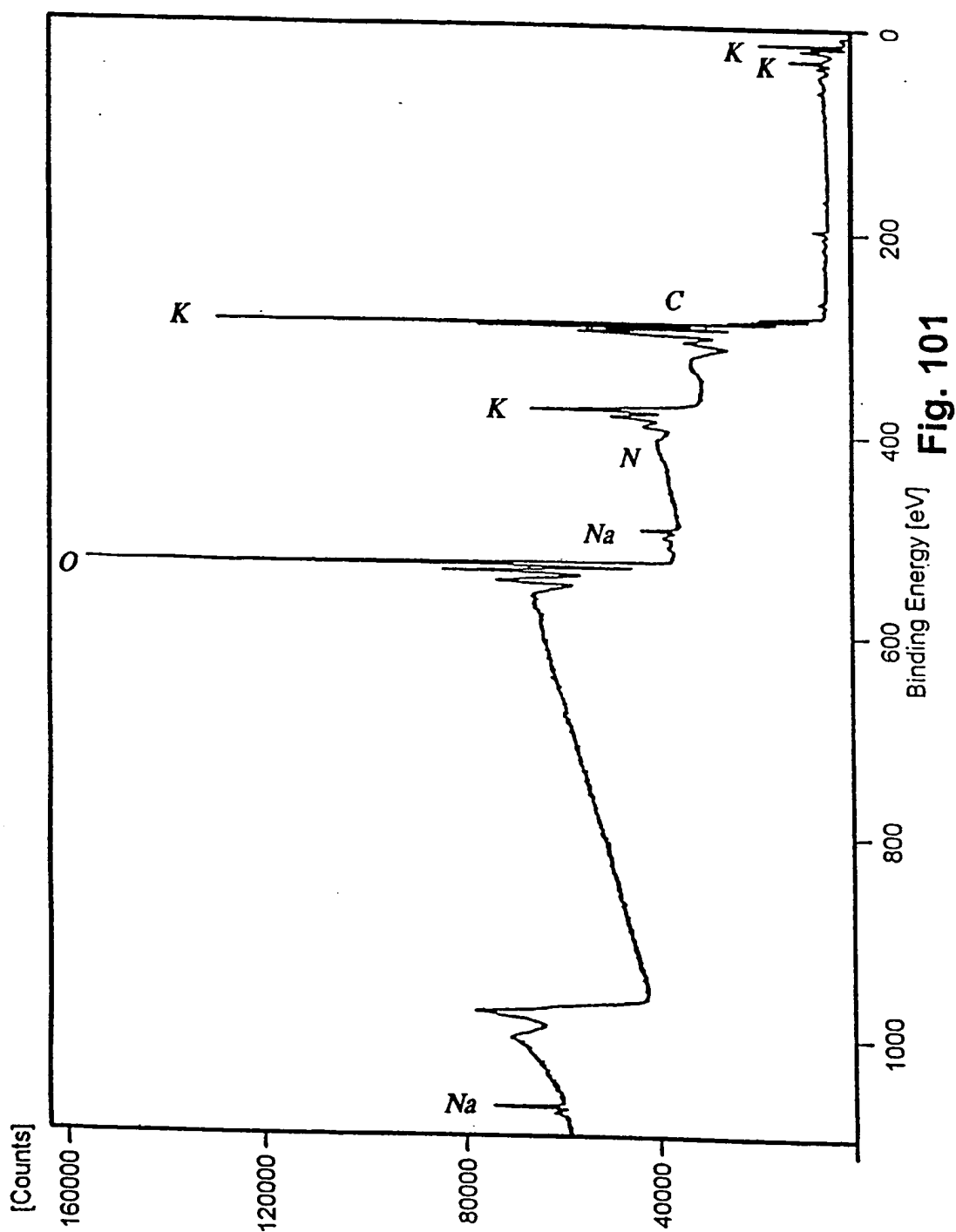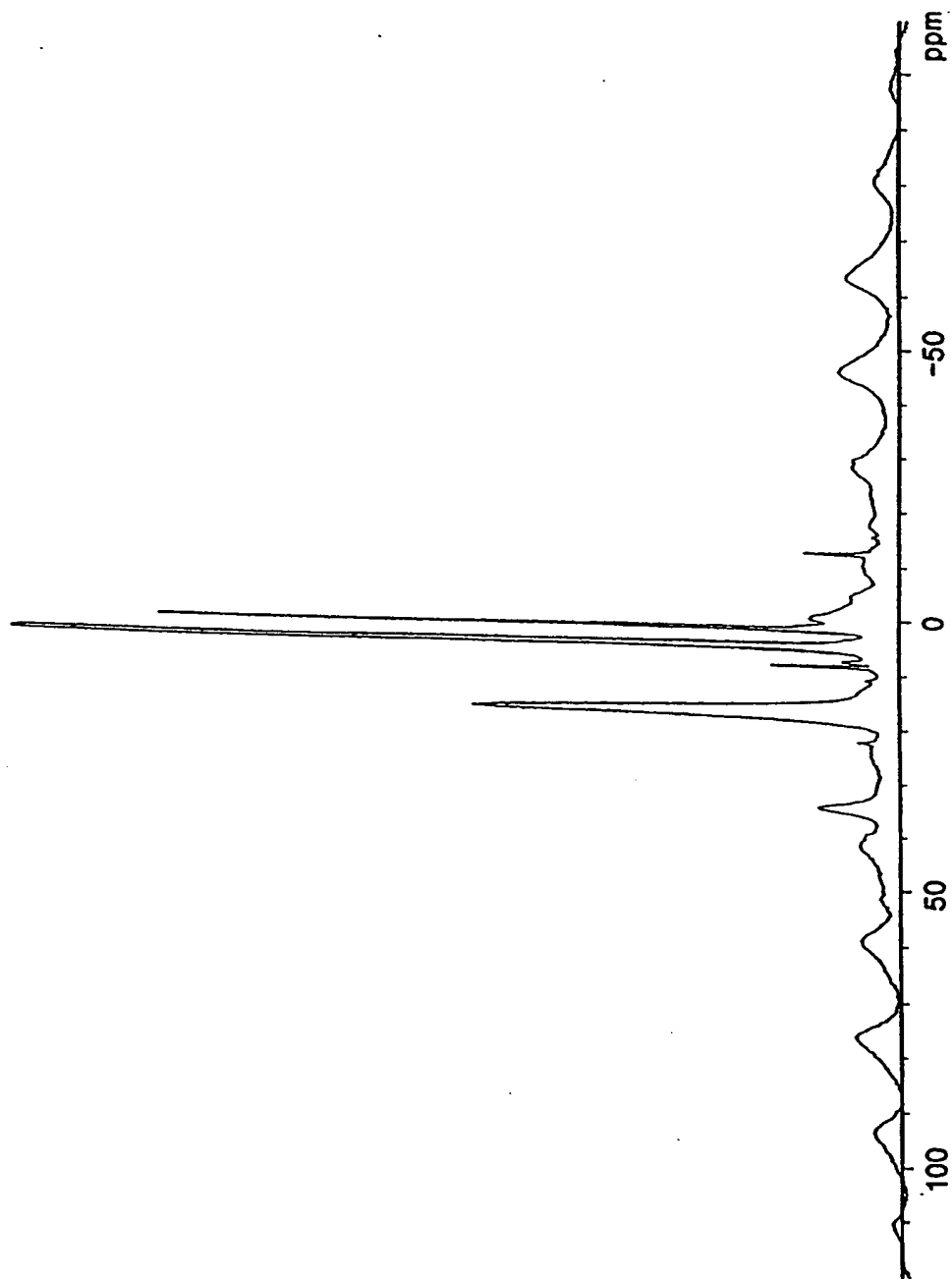
Binding Energy [eV]
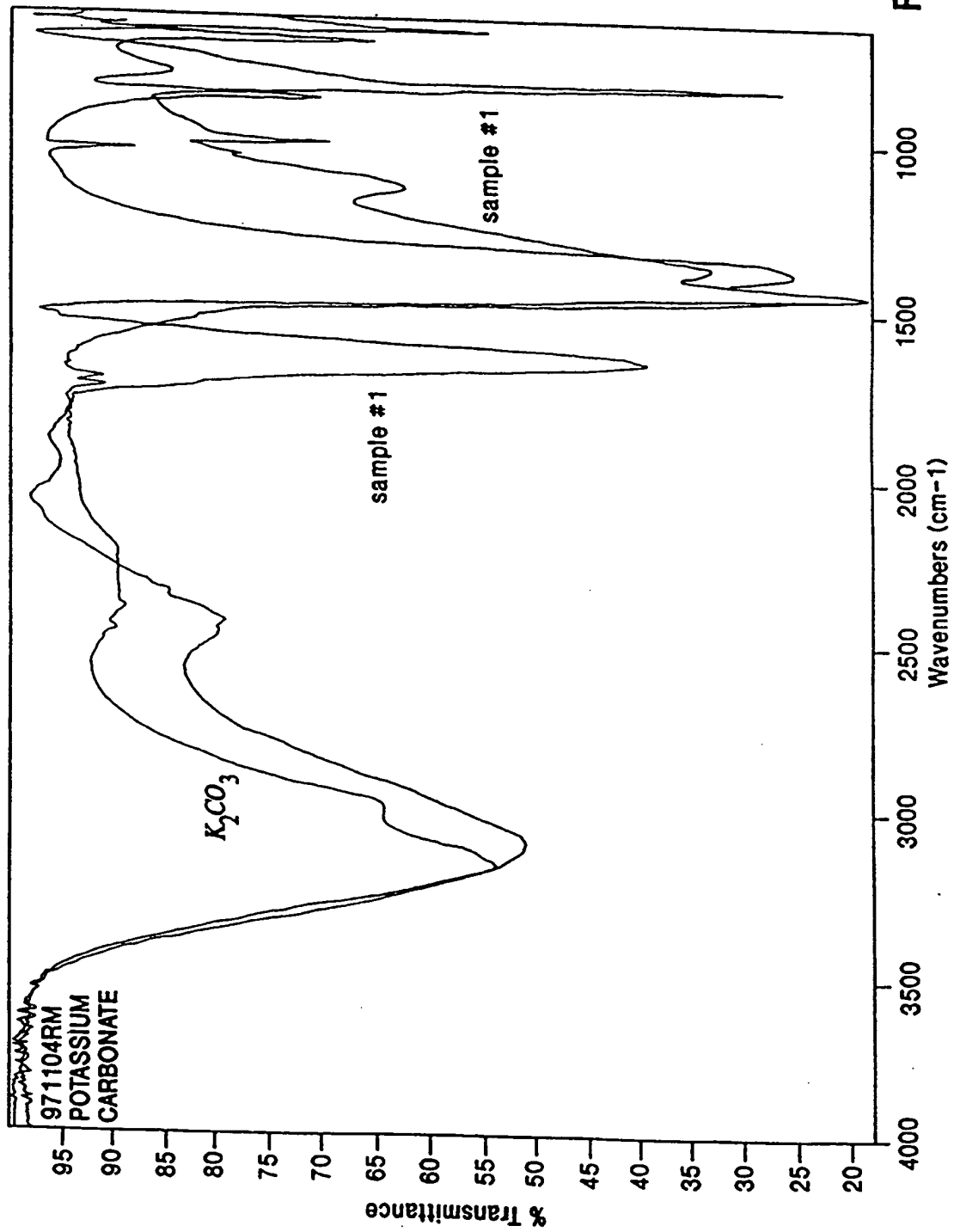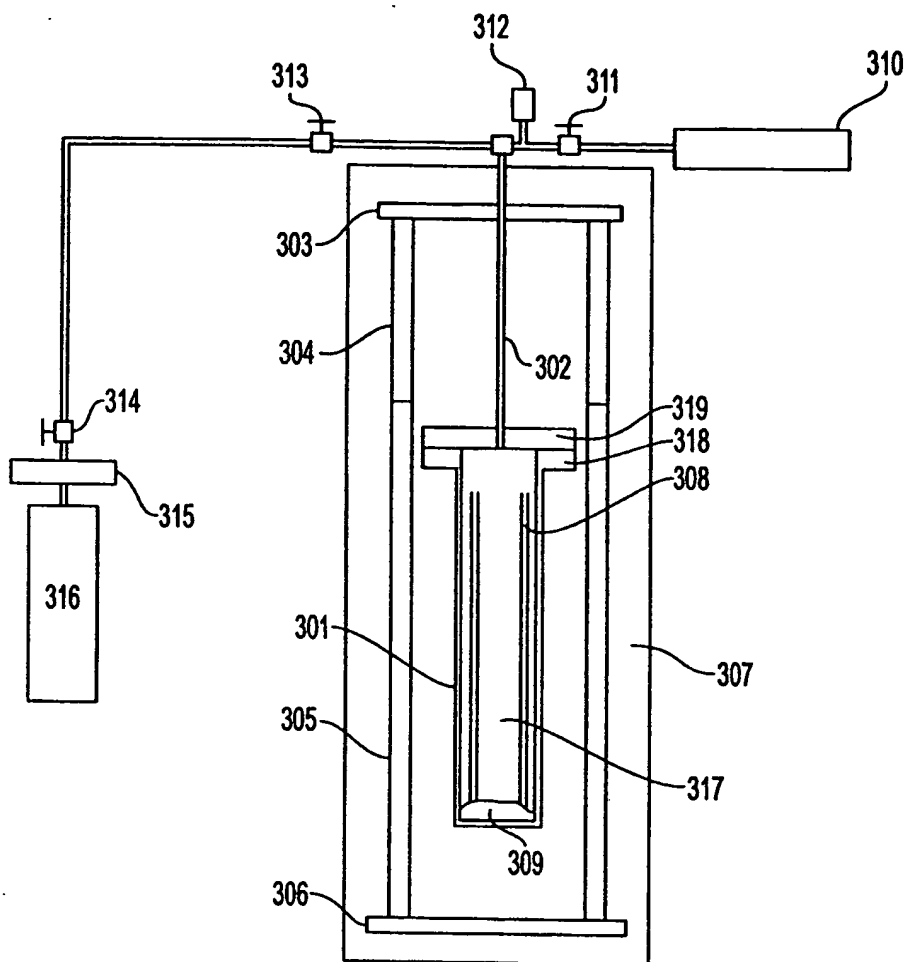
Fig. 102

Fig. 103

FIG. 104

FIG. 105A
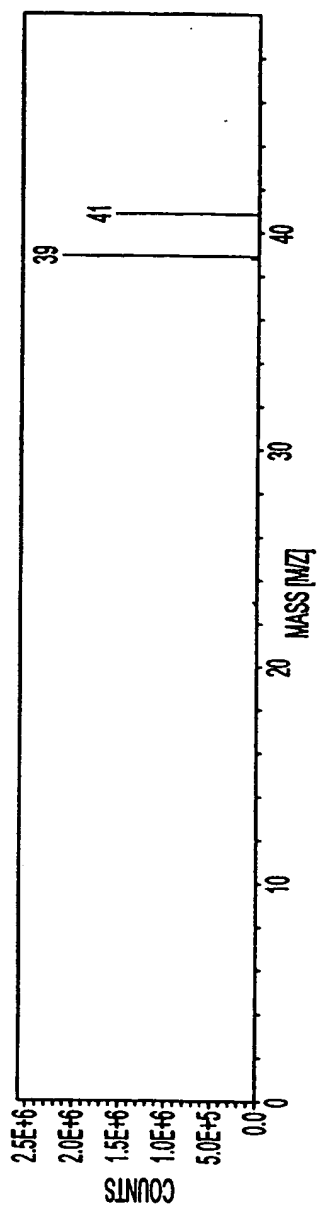
FIG. 105B
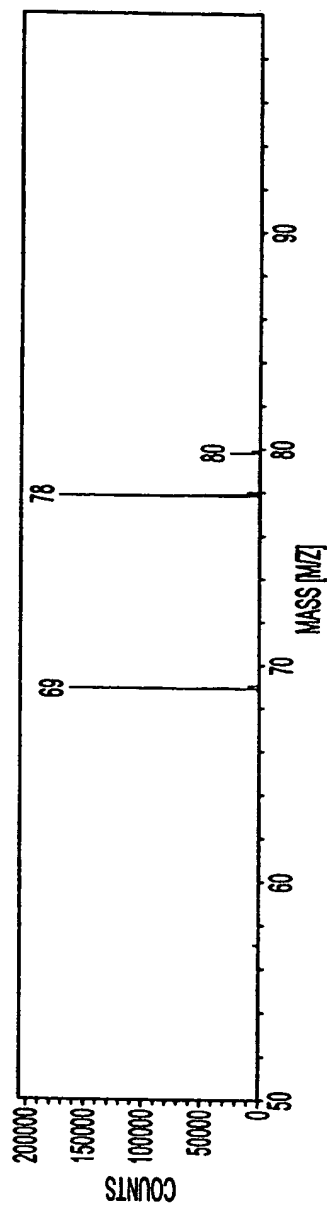
FIG. 105C
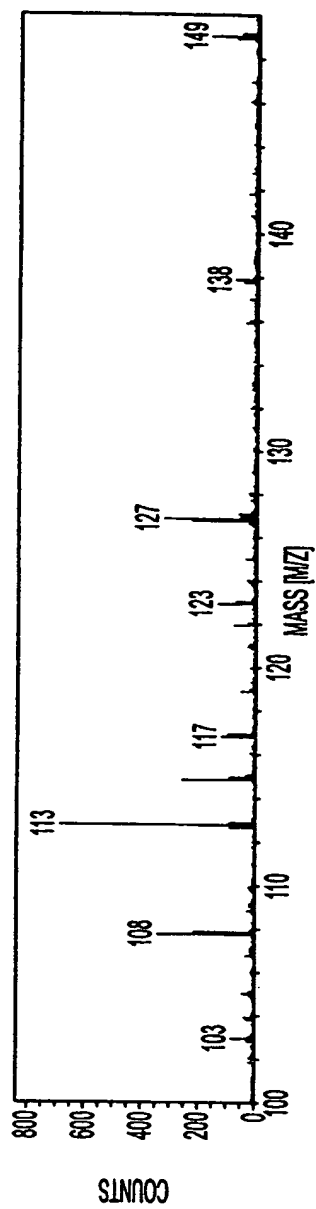
FIG. 105D

FIG. 106A

FIG. 106B

FIG. 106C

FIG. 106D

FIG. 107

FIG. 108

FIG. 109

FIG. 110

FIG. 111

FIG. 112

FIG. 113

FIG. 114

FIG. 115

FIG. 116

SURFACE SCIENCE LABORATORIES
1130 KI/TI
NUMBER OF SAMPLE SCANS: 250
NUMBER OF BACKGROUND SCANS: 250
RESOLUTION: 8.000
SAMPLE GAIN: 8.0
MIRROR VELOCITY: 1.8988
APERTURE: 150.00
TRANSMISSION
MWK DE3524

%TRANSMITTANCE

WAVENUMBERS (CM-1)

FIG. 117

FIG. 118

FIG. 119

FIG. 120

FIG. 121

FIG. 122

(51) International Patent Classification ^{7} : **C01B 6/00**	**A3**	(11) International Publication Number: **WO 00/07932** (43) International Publication Date: 17 February 2000 (17.02.00)

(54) Title: INORGANIC HYDROGEN AND HYDROGEN POLYMER COMPOUNDS AND APPLICATIONS THEREOF

(57) Abstract

Compounds are provided comprising at least one neutral, positive, or negative hydrogen species having a binding energy greater than its corresponding ordinary hydrogen species, or greater than any hydrogen species for which the corresponding ordinary hydrogen species is unstable or is not observed. Compounds comprise at least one increased binding energy hydrogen species and at least one other atom, molecule, or ion other than an increased binding energy hydrogen species. One group of such compounds contains one or more increased binding energy hydrogen species selected from the group consisting of H_n, H^-_n, and H^+_n where n is a positive integer, with the proviso that n is greater than 1 when H has a positive charge. Another group of such compounds may have the formula $[MH_mM'X]_n$ wherein m and n are each an integer, M and M' are each an alkali or alkaline earth cation, X is a singly or doubly negative charged anion, and the hydrogen content H_m of the compound comprises at least one increased binding energy hydrogen species. Method of forming the compounds and numerous applications are disclosed.

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7   C01B6/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7   C01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 99 05735 A (BLACK LIGHT POWER INC) 4 February 1999 (1999-02-04) page 235 -page 242	1-20
A	MILLS R L ET AL: "DIHYDRINO MOLECULE IDENTIFICATION" FUSION TECHNOLOGY,US,AMERICAN NUCLEAR SOCIETY. LAGRANGE PARK, ILLINOIS, vol. 25, January 1994 (1994-01), pages 103-119, XP002914535 ISSN: 0748-1896 page 105-106	1-118
A	WO 96 42085 A (HYDROCATALYSIS POWER CORP) 27 December 1996 (1996-12-27) claims 1-3,38	104-109

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☒ Further documents are listed in the continuation of box C.　　☒ Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 April 2000	27/04/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Clement, J-P

2

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 512 966 A (NELSON GUNNER E) 23 April 1985 (1985-04-23)	1-85, 99-103
A	US 4 986 887 A (GUPTA SANKAR DAS ET AL) 22 January 1991 (1991-01-22) column 2, line 24 - line 68	86

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9905735	A	04-02-1999	AU	8477298 A	16-02-1999
WO 9642085	A	27-12-1996	AU	705379 B	20-05-1999
			AU	6146596 A	09-01-1997
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